SVP
SOCIETY OF VERTEBRATE PALEONTOLOGY

# 83RD ANNUAL MEETING

**SVP 2023 PROGRAM GUIDE**

Duke Energy Convention Center | Cincinnati, Ohio USA
October 18 – 21, 2023

SOCIETY OF VERTEBRATE PALEONTOLOGY
83RD ANNUAL MEETING
CINCINNATI 2023

# 83rd Annual Meeting

SVP
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## OCTOBER 2023 ABSTRACTS OF PAPERS

*Duke Convention Center • Cincinnati, Ohio, USA*
*October 18-21, 2023*

# DUKE ENERGY CONVENTION CENTER MAP

*Ballroom Level*


- Auction Event
  Awards Banquet/After Party
- Posters and Exhibits
- Poster Meet & Greet – Foyer is located outside of Grand Ballroom A / B
  Registration Desk will be located on the third floor in the foyer across from the Men / Women Restrooms
- 3 Concurrent Session Rooms
- Restrooms (Men and Women)

SVP SOCIETY OF VERTEBRATE PALEONTOLOGY

## DUKE ENERGY CONVENTION CENTER MAP

*Meeting Room Level*


- Student Round Table – Room 232
  Child Care – Rooms 237-238
- Committee Meetings – Rooms 260-262
- Speaker Ready Room – Room 252

## DUKE ENERGY CONVENTION CENTER MAP

*Exhibit Hall Level*


Main Entrance – by the Starbucks logo at the bottom right corner

## WELCOME TO CINCINNATI

The Host Committee of the 83rd Annual Meeting is delighted to welcome all participants to the Society of Vertebrate Paleontology's 2023 meeting in the Queen City, Cincinnati, Ohio, USA. The meeting will take place at the Duke Energy Convention Center, located just blocks from the banks of the Ohio River.

This will be the first annual meeting of the Society of Vertebrate Paleontology held in Cincinnati and we are excited for your arrival. This year's meeting is co-hosted by Cincinnati Museum Center and the University of Cincinnati. Cincinnati is a hub of paleontology in the Mid-West of the USA with more per capita professional paleontologists in the metro region than any other area of the country. The Cincinnatian Series of Late Ordovician rocks underlying the city is internationally known for the abundance, diversity, and preservational quality of its fossils. After 150 years of intensive study, it continues to be a natural laboratory for scientists interested in the history of our planet and questions of deep time, biodiversity, climate change, and evolution.

Cincinnati Museum Center has a legacy of discovery 200 years in the making, from the founding of the Western Museum Society in 1818 to today's award-winning multi-museum complex. Housed in Cincinnati Union Terminal, an art deco train station and National Historic Landmark, Cincinnati Museum Center continues to bring the world to Cincinnati through its millions of specimens, artifacts, archival materials and artworks. Its first employee was a relatively unknown artist, John James Audubon, who was hired in 1819 as a taxidermist and background painter. During his brief time in Cincinnati, Audubon began his multi-volume masterwork Birds of America, cementing himself as a world-renowned wildlife artist. After two years of fundraising and collections acquisition, the Western Museum, the predecessor to CMC's Museum of Natural History & Science, opened in 1820, the first public science museum west of the Allegheny Mountains.

The University of Cincinnati is a public research university founded in 1819 as Cincinnati College. It is the oldest institution of higher education in Cincinnati and has an annual enrollment of over 44,000 students, making it the second largest university in Ohio. The Department of Geosciences is a nationally ranked program with a proud history of paleontological research and instruction. To celebrate Charles Darwin's 200th birthday, the University of Cincinnati hosted the 2009 North American Paleontological Convention.

The Vertebrate Paleontology Collection of Cincinnati Museum Center is housed at the Geier Collections & Research Center and comprises over 30,000 specimens, with special emphasis on Paleozoic and Pleistocene material from the middle Ohio Valley tri-state area (Ohio, Kentucky, Indiana), but with historic comparative materials from around the world. Also represented are significant holdings from Mesozoic marine deposits of the US Western Interior and mid-continental terrestrial fossils, notably from the Morrison and Hell Creek formations.

## WELCOME TO CINCINNATI - Continued

Cincinnati is also home to the world's longest continually operating amateur paleontology society, the Dry Dredgers Association of Amateur Geologists and Fossil Collectors, founded in 1942. The Kentucky Paleontological Society, based in Lexington, Kentucky, operates in the area and collaborates with the Cincinnati community on numerous projects. The collaborative approach and atmosphere of mutual respect that exists between the amateur community, university scientists, and museum professionals in Cincinnati makes our city an excellent venue for the dissemination of paleontological knowledge and the continued understanding of, and respect for, evidence-based approaches to science and public policy.

A short drive from downtown is Big Bone Lick State Historic Site, rightly described as the birthplace of American vertebrate paleontology. It was here in 1739 that European explorers were first made aware of the existence of Pleistocene fossils that would later figure prominently in the history of science, documenting for example, the concepts of extinction, comparative morphology, climate change, and evolution. William Clark, at the behest of Thomas Jefferson, conducted the first organized paleontological excavation in the Americas here in 1807, while Charles Lyell visited the site in 1842.

Cincinnati is a fun, dynamic, quirky, sophisticated, and thriving city with old-world charm on the banks of the Ohio River and a metro population of over 2 million. Seven fortune 500 companies call the area home. Cincinnati is in the midst of an exciting renaissance with a convergence of developments, entertainment districts, historic architectural renovations, parks, restaurants, museums, and a growing residential population downtown. Cultural attractions of interest to visitors include the Cincinnati Art Museum, Taft Museum of Art, Music Hall, National Underground Railroad Freedom Center, Contemporary Arts Center, 21C Museum Hotel, Aronoff Center for the Arts, Cincinnati Zoo and Botanical Gardens, The Banks, Over-the Rhine historic and entertainment district, Newport Aquarium, and of course, Cincinnati Museum Center, all in or in close proximity to downtown. A free public streetcar system is a convenient way to access dining and entertainment in the urban core.

We invite everyone to attend the Welcome Reception at the Cincinnati Museum Center where we will highlight the city's rich heritage of paleontological research, collections, and education. We hope you will enjoy all that Cincinnati has to offer during the 83rd Annual Meeting of the Society of Vertebrate Paleontology!

**Glenn Storrs**
SVP 83rd Annual Meeting Host Committee Co-Chair

**Joshua Miller**
SVP 83rd Annual Meeting Host Committee Co-Chair

## PRESENTATION POLICIES

SVP Abstracts are reviewed by the Program Committee and members of the Education & Outreach, Government Affairs, Preparators', Romer Prize, and Colbert Committees as appropriate. Authors are responsible for the technical content of their articles.

Unless specified otherwise, coverage of abstracts presented orally at the Annual Meeting is strictly prohibited until the start time of the presentation, and coverage of poster presentations is prohibited until the relevant poster session opens for viewing. As defined here, "coverage" includes all types of electronic and print media; this includes blogging, tweeting, advanced online publication, and other intent to communicate or disseminate results or discussion presented at the SVP Annual Meeting.

Still photography, video and/or audio taping, or any other electronic recording at the SVP Annual Meeting is strictly prohibited, with the exception of the designated SVP press event. The SVP reserves the right to engage professional photographers or audio/videotape professionals to archive sections of the Meeting for the Society's use.

Editorial policies for unpublished work: If you are planning to submit, or have submitted, your work to a journal that has embargo policies, be sure you are familiar with any restrictions they may impose on disseminating it before publication.

*Please address any questions about program practices to the Program Committee or to the Executive Committee.*

### CITING AN ABSTRACT IN THE 2023 SVP PROGRAM AND ABSTRACTS BOOK

This Program and Abstracts Book is an official supplement to the online version of the *Journal of Vertebrate Paleontology*. The citation format for an abstract printed in this book is: *Journal of Vertebrate Paleontology, Program and Abstracts, 2023,* <insert page number here>.

## PRESENTATION POLICIES - Continued

### SVP CODE OF CONDUCT

Please familiarize yourself with SVP's Code of Conduct as well as our supplemental COVID Code of Conduct. The Society of Vertebrate Paleontology (SVP) is dedicated to providing a courteous, professional, harassment-free conference experience for everyone, regardless of gender, gender identity and expression, sexual orientation, disability, physical appearance, race, or age. Demeaning, abusive, harassing, or threatening behavior towards other attendees, staff or the public is not permitted in either personal or electronic interactions. Personal and electronic interactions should be professional, rational, and mutually respectful at all conference events, both formal and informal. Intellectual property should be respected by not disseminating photographs, recordings, or other reproductions of presentations or artwork without permission of the author.

### EXPECTED BEHAVIOR

Treat one another with respect, consideration, and dignity regardless of gender, gender identity and expression, sexual orientation, marital or parental status, age, immigration status, disability, neurodiverse status, physical appearance, body size, race, ethnicity, nationality, religious affiliation, socioeconomic background, educational background, career stage, or military service.

- Questions and discussions should be respectful and constructive and focus on ideas rather than individuals.
- Comments or behaviors that may reasonably be assumed to have the effect of creating, contributing to, or maintaining an environment that is hostile toward or damaging to a person or group are prohibited, no matter whether they are made directly (e.g., in person or directly online) or indirectly (e.g., via social media).
- Do not use legal intoxicants to the extent that your ability to act professionally and follow this Code of Conduct is compromised.
- Do not take or disseminate photographs, recordings, or reproductions of materials presented as part of the Annual Meeting without express permission of the author(s).

Obey the rules and policies of any SVP-contracted facilities or services utilized during the meeting or anywhere your SVP badge/affiliation is on display.

## PRESENTATION POLICIES - Continued

### UNACCEPTABLE BEHAVIOR

- Harassment, intimidation, or discrimination in any form will not be tolerated.
- Physical or verbal abuse of any meeting participant.
- Examples of unacceptable behavior include, but are not limited to disparaging verbal comments or gestures related to gender, gender identity and expression, sexual orientation, disability, age, physical appearance, body size, race, religion, national origin.
- Epithets, slurs, or negative stereotyping; threatening, intimidating, or hostile acts; denigrating jokes; display or circulation of written graphic material that denigrates or shows hostility or aversion towards an individual or group. Harassment intended in a joking manner still constitutes unacceptable behavior.
- Inappropriate use of nudity and/or sexual images in public spaces or in presentations.
- Threatening or stalking any meeting participant.
- Inappropriate physical contact.
- Unwelcome sexual attention, including sexual advances or propositions; verbal comments or physical actions of a sexual nature; sexually degrading words used to describe an individual; a display of sexually suggestive objects or pictures; sexually explicit jokes.
- Disruption of talks at oral or poster sessions, in the exhibit hall, or at other events organized by SVP at the meeting venue, hotels, or other SVP-contracted facilities.
- Invasive photography or recording, including no photographs or recordings of minors (under 18 years of age) without explicit permission from guardians.
- Recording or photography of talks or posters without express permission from the authors.

Anyone requested to stop unacceptable behavior is expected to comply immediately. Retaliation against any individual who reports harassment or assists in an investigation will not be tolerated and is also subject to disciplinary action.

# PRESENTATION POLICIES - Continued

## REPORTING AN ALLEGATION OF CODE OF CONDUCT VIOLATION

If you witness or experience prohibited behavior, SVP provides several ways that you can submit a report. Allegations of misconduct must be submitted in writing (see "What to include in a report") via one of the following:

1. Anonymous or non-anonymous reports may be submitted through the NAVEX Platform accessible here.
2. Non-anonymous reports may be submitted to the Ethics Committee using safesvp@vertpaleo.org.
3. Non-anonymous reports may also be submitted in writing to:

   Chair of Ethics Committee
   Society of Vertebrate Paleontology
   1660 International Drive, Suite 600
   McLean, VA 22102 USA

## WHAT TO INCLUDE IN AN ALLEGATION REPORT

All allegations must be made in writing in one of the three ways described in the previous section. Allegation reports must contain the following:

1. Unless this is an anonymous report via the NAVEX Platform, the name and affiliation of the individual(s) submitting the allegation.
2. Name(s) of individuals alleged to have engaged in the prohibited behavior(s), if known, or as much identifying information as possible.
3. If there is a victim (and if this is not an anonymous report by the victim), then include the name of the victim(s) and affiliation when possible.
4. Description of the allegation that includes the date(s) and circumstances of the alleged ethics violation. This should include the type of prohibited behavior(s) as defined in the Code of Ethics that is being alleged. Include names and affiliations of witnesses, when possible.
5. Any documentation or other relevant items with a description of how each item relates to the allegation.
6. A statement of any real or perceived conflicts of interest related to any party named in the allegation (e.g., reporters, victims, alleged perpetrators, witnesses) and any members of the Ethics Committee or Executive Committee to ensure a fair and unbiased process.

Allegations may be returned if they do not contain the above information.

## SVP CODE OF CONDUCT - Continued

### WHAT IF YOU NEED IMMEDIATE HELP DURING AN SVP EVENT?

If you witness a crime or behavior that is an immediate threat to public safety, make sure you are safe and then call emergency services (e.g., 911 in the US).

If you are experiencing or witness prohibited behavior that is not an immediate threat to public safety during an SVP event (meeting, fieldtrip, symposium, online event, etc.), but you need to report DURING the event to stop the observed behavior, please alert the leader of that event immediately (e.g., fieldtrip leader, online event organizer) and, as soon as possible, contact the Vice President/Chair of the Ethics Committee Stuart Sumida (ssumida@csusb.edu), anyone on the SVP Executive Committee, or who is wearing a “Safe SVP” button or email safesvp@vertpaleo.org. Once you are able, please submit an official written report documenting what happened using one of the above three listed methods of reporting and including “What to Include in an Allegation Report”.

### REQUIRED REPORTERS

Society members acting in leadership positions, whether elected (Ex Comm members), appointed (e.g., committee members) or temporary (e.g., fieldtrip leaders, symposium organizers), are required to report any incidents of prohibited behavior that they observe directly or that are reported to them. They must document the incident and any action(s) taken. This report will be submitted to the Ethics Committee to determine whether or not actions taken were appropriate and whether there is need for additional sanctions.

# SOCIAL MEDIA GUIDELINES

## PLEASE READ BEFORE YOU TWEET (OR BLOG, OR FACEBOOK, OR INSTAGRAM…)

The Society of Vertebrate Paleontology encourages open discussion on social media and other outlets at our annual meeting. In order to find a balance between embracing social media and protecting authors' work, we set forth the following guidelines:

- SVP has an embargo in place on discussing presentations until the beginning of the talk or poster session. Please do not discuss presentations until this time if you do not have the authors' permission to do so.
- This embargo exists to protect the authors. As an author, you have permission to break your own embargo or permit someone else to do the same. This includes discussing your own presentation online, posting slides or posters, etc. However, to protect yourself, make sure you are aware of any potential future publisher's policies about early dissemination of work.
- Do not photograph or videotape a talk or poster without the authors' express permission. Never post any images or video without the authors' permission.
- While the default assumption is to allow open discussion of SVP presentations on social media, please respect any request by an author to not disseminate the contents of their talk. The following icon may be downloaded from the SVP website for inclusion on slides or posters to clearly express when an author does not want their results posted:

We want to thank everyone for following these basic guidelines for online posts of all kinds. As a reminder, the official hashtag of the meeting is #2023SVP. We look forward to seeing your thoughts and discussion online!

## 2023 SVP SCHEDULE OF EVENTS

*All events are held at the Duke Energy Center unless**

### TUESDAY, OCTOBER 17

| TIME | EVENT | LOCATION |
|---|---|---|
| 2:00 pm – 7:00 pm | **Registration Open** | *3rd Floor Foyer (across from bathrooms)* |
| 8:00 pm – 9:30 pm | **Special Lecture by Thane Maynard**<br>*The Nature of Hope* | **National Underground Railroad Freedom Center* |

### WEDNESDAY, OCTOBER 18

| TIME | EVENT | LOCATION |
|---|---|---|
| 7:00 am – 6:00 pm | **Registration Open** | *3rd Floor Foyer (across from bathrooms)* |
| 8:00 am – 12:15 pm | **Technical Session 1: Sauropod & Ornithischian Dinosaurs**<br>**Technical Session 2: Early Mammals & Carnivora**<br>**Technical Session 3: Fishes & Amphibians** | *Junior Ballroom A/B*<br>*Junior Ballroom C*<br>*Junior Ballroom D* |
| 9:30 am – 6:30 pm | **Exhibit and Poster Viewing Hours**<br>**Colbert Prize Competition Posters** *(B1-B24)*<br>**2020-2022 Graff Award Posters** *(B25-B27)*<br>**Paleontological Management Posters** *(B28-B53)*<br>**Poster Session 1** *(B54-B97)* | *Grand Ballroom A* |
| 12:30 pm – 1:30 pm | **National Science Foundation Research and Training Opportunities for Vertebrate Paleontologists**<br>Matthew Herron, Program Director,<br>National Science Foundation Division of Biological Infrastructure | *Junior Ballroom C* |
| 1:45 pm – 4:15 pm | **Technical Session 4: Dinosaur Soft Tissues**<br>**Technical Session 5: Ungulates**<br>**Technical Session 6: Marine Reptiles** | *Junior Ballroom A/B*<br>*Junior Ballroom C*<br>*Junior Ballroom D* |
| 4:30 pm – 6:30 pm | **Exhibits/Poster Mixer**<br>Authors will be Present at the Following Posters:<br>**Colbert Prize Competition Posters**<br>**2020-2022 Graff Award Posters**<br>**Paleontological Management Posters**<br>**Poster Session 1** | *Foyer outside of Grand Ballroom A/B* |
| 7:00 pm – 10:00 pm | **Welcome Reception** | **Cincinnati Museum Center* |

# 2023 SVP SCHEDULE OF EVENTS

*All events are held at the Duke Energy Center unless**

## THURSDAY, OCTOBER 19

| TIME | EVENT | LOCATION |
|---|---|---|
| 8:00 am – 6:00 pm | **Registration Open** | *3rd Floor Foyer (across from bathrooms)* |
| 8:00 am – 12:15 pm | **Romer Prize Session**<br>**Technical Session 7: Birds**<br>**Preparators' Session** | *Junior Ballroom A/B*<br>*Junior Ballroom C*<br>*Junior Ballroom D* |
| 9:30 am – 6:30 pm | **Exhibit and Poster Viewing Hours**<br>**Colbert Prize Competition Posters** *(B1-B24)*<br>**2020-2022 Graff Award Posters** *(B25-B27)*<br>**Preparators' Poster Session** *(B98-B105)*<br>**Poster Session 2** *(B106-B170)* | *Grand Ballroom A* |
| 1:45 pm – 4:15 pm | **Symposium: Theropod Flight Origins**<br>**Technical Session 8: Mammal Paleoecology**<br>**Technical Session 9: Sauropsids** | *Junior Ballroom A/B*<br>*Junior Ballroom C*<br>*Junior Ballroom D* |
| 4:30 pm – 6:30 pm | **Exhibits/Poster Mixer**<br>Authors will be Present at the Following Posters:<br>**Preparators' Poster Session** *(B98-B105)*<br>**Poster Session 2** *(B106-B170)* | *Foyer outside of Grand Ballroom A/B* |
| 7:30 pm – 11:30 pm | **Student and Postdoc Committee Roundtable Forum** | *Room 232* |

SVP SOCIETY OF VERTEBRATE PALEONTOLOGY

## 2023 SVP SCHEDULE OF EVENTS

*All events are held at the Duke Energy Center unless**

### FRIDAY, OCTOBER 20

| TIME | EVENT | LOCATION |
|---|---|---|
| 8:00 am – 5:00 pm | **Registration Open** | *3rd Floor Foyer (across from bathrooms)* |
| 8:00 am – 12:15 pm | **Technical Session 10: Euarchontoglires & Xenarthra** | *Junior Ballroom A/B* |
| | **Technical Session 11: Archosaurs** | *Junior Ballroom C* |
| | **Technical Session 12: Methods & Paleohistology** | *Junior Ballroom D* |
| 9:30 am – 6:30 pm | **Exhibit and Poster Viewing Hours**<br>**Colbert Prize Competition Posters** *(B1-B24)*<br>**2020-2022 Graff Award Posters** *(B25-B27)*<br>**Education and Outreach Posters** *(B171-B188)*<br>**Poster Session 3** *(B189-B245)* | *Grand Ballroom A* |
| 1:45 pm – 4:15 pm | **Technical Session 13: Fishes – Actinopterygians** | *Junior Ballroom A/B* |
| | **Technical Session 14: Crocodylomorphs & Turtles** | *Junior Ballroom C* |
| | **Technical Session 15: Paleoecology & Paleoclimatology** | *Junior Ballroom D* |
| 4:30 pm – 6:30 pm | **Exhibits/Poster Mixer**<br>Authors will be Present at the Following Posters:<br>**Education and Outreach Posters** *(B171-B188)*<br>**Poster Session 3** *(B189-B245)* | *Foyer outside of Grand Ballroom A/B* |
| 6:30 pm – 11:30 pm | **Annual Benefit Auction and Social** | *Grand Ballroom B* |

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## 2023 SVP SCHEDULE OF EVENTS

*All events are held at the Duke Energy Center unless**

### SATURDAY, OCTOBER 21

| TIME | EVENT | LOCATION |
|---|---|---|
| 8:00 am – 2:00 pm | **Registration Open** | *3rd Floor Foyer (across from bathrooms)* |
| 8:00 am – 12:15 pm | **Technical Session 16: Theropods – I** | *Junior Ballroom A/B* |
| | **Technical Session 17: Afrotheria & Mammal Macroevolution** | *Junior Ballroom C* |
| | **Technical Session 18: Synapsids** | *Junior Ballroom D* |
| 9:30 am – 6:30 pm | **Exhibit and Poster Viewing Hours**<br>**Colbert Prize Competition Posters** *(B1-B24)*<br>**2020-2022 Graff Award Posters** *(B25-B27)*<br>**Poster Session 4** *(B246-B323)* | *Grand Ballroom A* |
| 1:45 pm – 4:15 pm | **Technical Session 19: Theropods – II** | *Junior Ballroom A/B* |
| | **Technical Session 20: Marine Mammals & Bats** | *Junior Ballroom C* |
| | **Technical Session 21: Squamates** | *Junior Ballroom D* |
| 4:30 pm – 6:30 pm | **Exhibits/Poster Mixer**<br>Authors will be Present at the Following Posters:<br>**Poster Session 4** *(B246-B323)* | *Foyer outside of Grand Ballroom A/B* |
| 7:30 pm – 10:00 pm | **Awards Banquet**<br>*Ticket required for admittance* | *Grand Ballroom B* |
| 10:30 pm – 1:00 am | **After Hours Party** | *Junior Ballroom* |

## 2023 SVP FIELD TRIPS

**For Pre-registered Attendees*

| DAY / TIME | TRIP |
|---|---|
| Monday, October 16, 7:30 am – Tuesday, October 17, 8:00 pm | **Paleozoic Vertebrates of the Ohio River Valley Area** |
| Tuesday, October 17, 8:30 am – 6:00 pm | **Southern Ohio Prehistoric Earthwork Tour** |
| Tuesday, October 17, 9:00 am – 5:00 pm | **Big Bone Lick: Birthplace of American Vertebrate Paleontology** |
| Wednesday, October 18, 10:00 am – 12:00 pm | **Downtown Cincinnati Walking Tour** |
| Thursday, October 19, 10:00 am – 12:00 pm | **Downtown Cincinnati Walking Tour** |
| Saturday, October 21, 8:30 am – 6:30 pm | **Exploring a Sea without Fish: Late Ordovician Stratigraphy and Paleoecology of the Cincinnati Arch Region** |

## 2023 SVP WORKSHOPS

**For Pre-registered Attendees*

| DAY / TIME | TITLE | LOCATION |
|---|---|---|
| Tuesday, October 17, 9:00 am – 12:00 pm | **U.S. Intellectual Property Law for Paleontologists** | *Duke Energy Convention Center Room 232* |
| Tuesday, October 17, 9:00 am – 12:00 pm | **Public Engagement 101: Using Evidence-Based Practices to Enhance Your Skills at Engaging the Public in Informal Learning Environments** | *Duke Energy Convention Center Room 233* |
| Tuesday, October 17, 1:00 pm – 5:00 pm | **Evaluation 101: Is This Effective? Best Practices in Evaluating Education and Outreach Programing** | *Duke Energy Convention Center Room 232* |
| Tuesday, October 17, 1:00 pm – 5:00 pm | **Movement and Paleontology: Integrating Movement Arts to Explore and Communicate Paleontology** | *Duke Energy Convention Center Room 233* |

*For field trip and workshop pickup and dropoff location and time, please check with your workshop or field trip leader or check the mobile app.*

# TALKS SCHEDULE

## WEDNESDAY, OCTOBER 18

| TIME | JUNIOR BALLROOM A/B<br>*Sauropod & Ornithischian Dinosaurs* | JUNIOR BALLROOM C<br>*Early Mammals & Carnivora* | JUNIOR BALLROOM D<br>*Fishes & Amphibians* |
|---|---|---|---|
| 8:00 am | Moore | Davis | Liu |
| 8:15 am | Tsai | Panciroli | Zhu |
| 8:30 am | Vidal | Hoffmann | Brownstein |
| 8:45 am | Caputo | Weil | Long |
| 9:00 am | Whitlock | Rougier | Sharma |
| 9:15 am | Maidment | WITHDRAWN | Leong |
| 9:30 am | Bamforth | Bloch | Johanson |
| 9:45 am | Pol | Gaudin | Haridy |
| 10:00 am | | COFFEE | |
| 10:15 am | Nabavizadeh | Hoeflich | Falk |
| 10:30 am | DeVries | Koehler | Rossi |
| 10:45 am | Hannebaum | Rothschild | Igielman |
| 11:00 am | Dunfee | Wang | Xiong |
| 11:15 am | Dudgeon | Schubert | Creighton |
| 11:30 am | Bender | Hotchner | Kufner |
| 11:45 am | Chinzorig | Tseng | So |
| 12:00 pm | Theurer | Pardo | Marjanović |
| 12:15 pm – 1:30 pm | | LUNCH | |

| TIME | JUNIOR BALLROOM A/B<br>*Dinosaur Soft Tissues* | JUNIOR BALLROOM C<br>*Ungulates* | JUNIOR BALLROOM D<br>*Marine Reptiles* |
|---|---|---|---|
| 1:45 pm | Byrne | Funston | Liu |
| 2:00 pm | Morhardt | Silviria | Qiao |
| 2:15 pm | Boyd | Engelman | Clark |
| 2:30 pm | Joubarne | Bai | WITHDRAWN |
| 2:45 pm | Cerio | Wimberly | Hu |
| 3:00 pm | Wasserlauf | Robson | O'Keefe |
| 3:15 pm | Garderes | O'Brien | McGaughey |
| 3:30 pm | Yang | Grossman | Konishi |
| 3:45 pm | Fortner | Kirera | Kelley |
| 4:00 pm | McIntosh | Gaetano | Denham |

*SVP will not use closed captioning for talks during this meeting.*
*However, we encourage all speakers to add concise text to slides in talks to help people of all abilities get more from your talk.*

# 83RD ANNUAL MEETING

SVP SOCIETY OF VERTEBRATE PALEONTOLOGY

## TALKS SCHEDULE

### THURSDAY, OCTOBER 19

| TIME | JUNIOR BALLROOM A/B *Romer Prize Session* | JUNIOR BALLROOM C *Birds* | JUNIOR BALLROOM D *Preparators' Session* |
|---|---|---|---|
| 8:00 am | Kort | Clark | Duffy |
| 8:15 am | Lowi-Merri | Field | Gordon |
| 8:30 am | Woolley | Benito | Fox |
| 8:45 am | Steell | Kuo | Shinya |
| 9:00 am | Qin | Chen | Dougan |
| 9:15 am | Morgan | Dickson | Morley |
| 9:30 am | Kulik | Alger-Meyer | Avrahami |
| 9:45 am | Howard | O' Connor | Herzog |
| 10:00 am | | COFFEE | |
| 10:15 am | Smyth | Wilson | Hall |
| 10:30 am | Otoo | Caldwell | Moretti |
| 10:45 am | DeMers | Griffin | Lund |
| 11:00 am | Formoso | Navalon | Groenke |
| 11:15 am | Hogan | Holliday | Keillor |
| 11:30 am | Pommerening | Widrig | Householder |
| 11:45 am | Rowe | Kingwill | Anné |
| 12:00 pm | Keller | Slater | Dunn |
| 12:15 pm – 1:30 pm | | LUNCH | |

| TIME | JUNIOR BALLROOM A/B *Symposium: Theropod Flight Origins* | JUNIOR BALLROOM C *Mammal Paleoecology* | JUNIOR BALLROOM D *Sauropsids* |
|---|---|---|---|
| 1:45 pm | Chase | Smiley | Bazzana-Adams |
| 2:00 pm | Habib | Reuter | Butler |
| 2:15 pm | Pittman | Ward | WITHDRAWN |
| 2:30 pm | Baumgart | Fox | Van den Brandt |
| 2:45 pm | Jones | Lukens | Pugh |
| 3:00 pm | Grosmougin | Pirlo | Huttenlocker |
| 3:15 pm | Chotard | Shupinski | WITHDRAWN |
| 3:30 pm | Hefler | DeSantis | Jenkins |
| 3:45 pm | Pittman | Smith | Roberts |
| 4:00 pm | Dececchi | WITHDRAWN | Martinez |

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# TALKS SCHEDULE

## FRIDAY, OCTOBER 20

| TIME | JUNIOR BALLROOM A/B *Euarchontoglires & Xenarthra* | JUNIOR BALLROOM C *Archosaurs* | JUNIOR BALLROOM D *Methods & Paleohistology* |
|---|---|---|---|
| 8:00 am | Schroeder | Slibeck | Sereno |
| 8:15 am | Hunter | Stiegler | Yu |
| 8:30 am | Silcox | Sookias | Rhoda |
| 8:45 am | McNulty | Keeble | Huang |
| 9:00 am | Kirk | Peecook | Behrensmeyer |
| 9:15 am | de Vries | Roberts | Laker |
| 9:30 am | Kay | Sues | Powers |
| 9:45 am | Samuels | Foster | Meachen |
| 10:00 am | | COFFEE | |
| 10:15 am | Hensley | Cornille | D'Emic |
| 10:30 am | Strassberg | Goldsmith | Ke |
| 10:45 am | Socki | Haldar | Wosik |
| 11:00 am | Restrepo-Cortes | Patellos | Myhrvold |
| 11:15 am | Pansani | Armour Smith | Bijl |
| 11:30 am | Haupt | Unwin | Garros |
| 11:45 am | McAfee | Parsons | Freimuth |
| 12:00 pm | Zack | Perea | Li |
| 12:15 pm – 1:30 pm | | LUNCH | |

| TIME | JUNIOR BALLROOM A/B *Fishes - Actinopterygians* | JUNIOR BALLROOM C *Crocodylomorphs & Turtles* | JUNIOR BALLROOM D *Paleoecology & Paleoclimatology* |
|---|---|---|---|
| 1:45 | Figueroa | Wilberg | Foffa |
| 2:00 | Stack | Gunnin | Trinidad |
| 2:15 | Liu | Grand Pre | Suarez |
| 2:30 | Caron | Burke | Linzmeier |
| 2:45 | Miyashita | Margulis-Ohnuma | Olsen |
| 3:00 | Friedman | Salem | Krause |
| 3:15 | Maden | Lessner | Morley |
| 3:30 | Wilson | Hastings | Lechki |
| 3:45 | Liston | Ong | Naprstek |
| 4:00 | Lanzetti | Lively | Burger |

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## TALKS SCHEDULE

### SATURDAY, OCTOBER 21

| TIME | JUNIOR BALLROOM A/B *Theropods - I* | JUNIOR BALLROOM C *Afrotheria & Mammal Macroevolution* | JUNIOR BALLROOM D *Synapsids* |
|---|---|---|---|
| 8:00 am | Coppock | Simpson | Mann |
| 8:15 am | Longrich | Beard | Lungmus |
| 8:30 am | Adams | Cherney | Sumida |
| 8:45 am | Carr | Yang | Pardo |
| 9:00 am | Slowiak-Morkovina | Jukar | Thomas |
| 9:15 am | van Bijlert | Shirley | Sidor |
| 9:30 am | Wyenberg-Henzler | Grossnickle | Angielczyk |
| 9:45 am | Makovicky | Fraser | WITHDRAWN |
| 10:00 am | | COFFEE | |
| 10:15 am | Serio | Vitek | George |
| 10:30 am | Boekenheide | Magallanes | Whitney |
| 10:45 am | Lamanna | Smith | Abbott |
| 11:00 am | Ruebenstahl | Pizzini | Rawson |
| 11:15 am | Nye | Davidson | Kammerer |
| 11:30 am | Maddox | Weaver | Norton |
| 11:45 am | Hohman | Croft | Milner |
| 12:00 pm | WITHDRAWN | Carter | Brant |
| 12:15 pm – 1:30 pm | | LUNCH | |

| TIME | JUNIOR BALLROOM A/B *Theropods - II* | JUNIOR BALLROOM C *Marine Mammals & Bats* | JUNIOR BALLROOM D *Squamates* |
|---|---|---|---|
| 1:45 | Clawson | Harvell | Sullivan |
| 2:00 | Carrano | Rule | Benson |
| 2:15 | Ciudad Real Ballestero | Spiess | Jacisin |
| 2:30 | Larson | Gohar | Forcellati |
| 2:45 | D'Amore | Brand | Jameson |
| 3:00 | Johnson-Ransom | Nelson | Petermann |
| 3:15 | Warner-Cowgill | Boessenecker | Riegler |
| 3:30 | Boisvert | Matsui | Wilenzik |
| 3:45 | Chinzorig | Geisler | Head |
| 4:00 | Napoli | Perini | Burch |

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Henry Sharpe

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***"Life sized Dilophosaurus Sculpture"***
Brian Engh

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## List of Authors and Abstract Titles in Chronological Session Order

**WEDNESDAY MORNING, OCTOBER 18, 2023**
**TECHNICAL SESSION 1: SAUROPOD & ORNITHISCHIAN DINOSAURS**
**MEETING ROOM JUNIOR BALLROOM A/B**
**MODERATORS: Andrew Moore and Emily Bamforth**

**8:00** **A. Moore** NECKS TO NONE: ALLOMETRIC SCALING OF THE CERVICAL VERTEBRAL SERIES IN SAUROPOD DINOSAURS

**8:15** **H.P. Tsai** BRINGING UP BABY: ONTOGENETIC TRANSITION AT THE FEMORAL CHONDRO-OSSEOUS JUNCTIONS OF JURASSIC SAUROPODS

**8:30** **D. Vidal**, **P.C. Sereno**, **N.P. Myhrvold** TEMPORAL SEQUENCE AND DIVERSITY OF SAUROPOD DINOSAURS IN THE MIDDLE TO LATE JURASSIC IRHAZER SERIES OF NIGER

**8:45** **C. Caputo**, **M. Lamanna**, **P. Ullmann**, **G. Casal**, **L. Ibiricu**, **K. Lacovara** DESCRIPTION AND PHYLOGENETIC ANALYSIS OF A NEW TITANOSAURIAN SAUROPOD SPECIMEN FROM THE UPPER CRETACEOUS CERRO FORTALEZA FORMATION OF SOUTHERN PATAGONIA, ARGENTINA

**9:00** **J.A. Whitlock** NO MORE HORSING AROUND: A POSSIBLE EXPLANATION FOR THE UNUSUAL WEAR FACETS COMMONLY OBSERVED IN DIPLODOCOID SAUROPOD DINOSAURS.

**9:15** **S. Maidment** DIVERSITY CHANGE THROUGH TIME AND SPACE IN THE UPPER JURASSIC MORRISON FORMATION, WESTERN USA

**9:30** **E. Bamforth** EXPLORING THE ROLE OF EVOLVING FOREST COMPOSITION IN SHAPING DINOSAUR DIVERSITY PATTERNS IN THE CRETACEOUS OF NORTHERN ALBERTA, CANADA

**9:45** **D. Pol**, **M. Becerra**, **J.L. Carballido**, **M. Krause**, **M. Baiano**, **M. Pittman** NEW DINOSAUR DISCOVERIES IN THE LA COLONIA FORMATION: INSIGHTS INTO THE LATE CRETACEOUS FAUNA OF PATAGONIA BEFORE THE K-PG EXTINCTION EVENT

**10:15** **A. Nabavizadeh** EVOLUTION OF CRANIAL ADDUCTOR MUSCLE ORIENTATION IN ORNITHISCHIAN DINOSAURS AND ITS IMPLICATIONS FOR FEEDING MECHANISMS

**10:30** **R.P. DeVries**, **P.C. Sereno**, **A. Gamonal**, **N.S. Fontela** SMALL-BODIED ARMORED DINOSAUR FROM NIGER (IRHAZER SERIES: TIOURARÉN FORMATION) DOCUMENTS THE BASAL ACQUISITION OF QUADRUPEDAL POSTURE AND SUBADULT HERDING BEHAVIOR AMONG THYREOPHORANS (DINOSAURIA: ORNITHISCHIA)

**10:45** **Z. Hannebaum**, **D.J. Varricchio**, **L. Krumenacker** BENEATH THE FEET OF GIANTS: A CASE STUDY OF THE POPULATION DYNAMICS OF *ORYCTODROMEUS CUBICULARIS* AND *ORODROMEUS MAKELAI*, TWO POTENTIAL BURROWING DINOSAURS

**11:00** **D.R. Dunfee**, **R. Ridgely**, **M. Lamanna**, **L.M. Witmer** ONTOGENETIC ANALYSIS OF A JUVENILE BRAINCASE OF *DRYOSAURUS ELDERAE* (DINOSAURIA: ORNITHOPODA) FROM THE UPPER JURASSIC MORRISON FORMATION OF UTAH: NEW PHYLOGENETIC IMPLICATIONS FROM COMPUTED TOMOGRAPHY

**11:15** **T. Dudgeon**, **D. Evans** FINITE ELEMENT ANALYSIS HIGHLIGHTS CHANGES IN FEEDING MECHANICS IN A CRANIAL ONTOGENETIC SERIES OF *CORYTHOSAURUS CASUARIUS* (ORNITHOPODA: HADROSAURIDAE)

**11:30** **E.R. Bender**, **T.A. Gates**, **E. Johnson**, **L.E. Zanno** A NEW KRITOSAURIN HADROSAURID (DINOSAURIA: ORNITHOPODA) FROM THE LATE CAMPANIAN WILLIAMS FORK FORMATION OF COLORADO

**11:45** **T. Chinzorig**, **R. Takasaki**, **J. Yoshida**, **B. Buyantegsh**, **B. Mainbayar**, **R. Tucker**, **K. Tsogtbaatar**, **L.E. Zanno** THE OLDEST PACHYCEPHALOSAUR (ORNITHISCHIA: MARGINOCEPHALIA) FROM THE LOWER CRETACEOUS HUHTEEG FORMATION AT KHUREN DUKH LOCALITY IN SOUTHEASTERN MONGOLIA

**12:00** **B.C. Theurer**, **C. Sullivan** ONE OF THESE THINGS IS NOT LIKE THE OTHERS—OR IS IT? VARIATION IN PELVIC GIRDLE AND HINIDLIMB ELEMENTS OF CERATOPSID DINOSAURS

**WEDNESDAY MORNING, OCTOBER 18, 2023**
**TECHNICAL SESSION 2: EARLY MAMMALS & CARNIVORA**
**MEETING ROOM JUNIOR BALLROOM C**
**MODERATORS: Simone Hoffmann and Jonathan Bloch**

**8:00** **B.M. Davis**, **G.W. Rougier**, **B.E. Connelly** REINTERPRETATION OF THE DENTITION AND LOWER JAW OF THE ENIGMATIC BURROWING MAMMAL *FRUITAFOSSOR* BASED ON NEW MATERIAL FROM THE UPPER JURASSIC MORRISON FORMATION (GRAND COUNTY, UTAH, USA)

**8:15** **E. Panciroli**, **R. Benson**, **V. Fernandez**, **N. Fraser**, **M. Humpage**, **Z. Luo**, **E. Newham**, **S. Walsh** JURASSIC FOSSIL JUVENILE MAMMALIAFORM FROM SCOTLAND PROVIDES LIFE HISTORY CASE STUDY IN EARLY MAMMALS

**8:30** **S. Hoffmann**, **R. Shahid**, **P. Gill** THE STAPES OF THE BASAL MAMMALIAFORM *MORGANUCODON*

**8:45** **A. Weil**, **A. Claxton** ETHMOTURBINALS OF LATE CRETACEOUS *MENISCOESSUS ROBUSTUS* (MULTITUBERCULATA: CIMOLODONTA) AND PALEOECOLOGICAL INFERENCE

**9:00** **G.W. Rougier**, **B.E. Connelly**, **L. Apella Guiscafré** A MESUNGULATID MAXILLA FROM THE LATE CRETACEOUS LA COLONIA FORMATION (CHUBUT PROVINCE, ARGENTINA) SHOWING EVIDENCE OF TOOTH REPLACEMENT: THE MOLAR-PREMOLAR BOUNDARY IN DRYOLESTOIDS AND STEM THERIANS.

**9:15** **WITHDRAWN**

**9:30** **J.I. Bloch**, **C. Suarez**, **A. Rincon**, **M.C. Vallejo-Pareja**, **J. Head**, **A.K. Hastings**, **E.A. Cadena**, **C. Jaramillo** NEW METATHERIANS FROM THE PALEOCENE-EOCENE OF TROPICAL SOUTH AMERICA

**9:45** **T.J. Gaudin**, **K.D. Rose**, **R. Rabenstein**, **J. Habersetzer** NEW FORELIMB DETAILS OF *EUROTAMANDUA*, PURPORTED ANTEATER FROM THE MIDDLE EOCENE OF MESSEL, GERMANY, REVEAL EXTRAORDINARY SIMILARITIES TO PALAEANODONTS (PHOLIDOTAMORPHA), NOT TO XENARTHRA

**10:15** **J. Hoeflich**, **J. Liu** ESTIMATING HEARING CAPABILITY OF CARNIVORANS USING DYNAMIC FINITE ELEMENT METHODS

**10:30** **K.M. Koehler**, **J. Faith**, **D.R. Braun**, **A.F. Schwartz**, **K. O'Brien**, **K. Sokolowski**, **B. Davies**, **D. Stynder**, **L. DeSantis** DENTAL MICROWEAR TEXTURE ANALYSIS OF PLEISTOCENE CARNIVORES ON THE WEST COAST OF SOUTH AFRICA

**10:45** **B.M. Rothschild**, **G. Argyros** SURFACE DEFECTS/PORES/PITS AND THEIR IMPLICATIONS: A SURVEY OF CARNIVORE FRONTAL AND PARIETAL BONE SURFACES

**11:00** **X. Wang**, **R.J. Emry**, **C.A. Boyd**, **J.J. Person**, **S.C. White**, **R.H. Tedford** AN EARLY URSOID, *EOARCTOS VORAX*, FROM FITTERER RANCH, NORTH DAKOTA (EARLY OLIGOCENE) AND EARLY DIVERGENCE OF NORTH AMERICAN BASAL ARCTOIDS (CARNIVORA, CANIFORMIA)

**11:15** **B.W. Schubert**, **J.X. Samuels**, **L.H. Soibelzon**, **S.C. Wallace**, **E. Bogner** THE EARLY FOSSIL RECORD AND DIVERSIFICATION OF SHORT-FACED BEARS (URSIDAE, TREMARCTINAE) IN NORTH AMERICA

**11:30** **A. Hotchner**, **J. Meachen** REEVALUATION OF THE ECOLOGICAL NICHE OF THE LATE PLEISTOCENE FELID *MIRACINONYX TRUMANI*

**11:45** **Z. Tseng** SHIFT HAPPENS: BENDING STRENGTH DECREASE DURING THE ERUPTION OF THE PERMANENT SABER IN *SMILODON FATALIS*

**12:00** **J.R. Pardo**, **L. DeSantis** THE CHANGING MENU OF SABERTOOTH CATS: DIETARY ECOLOGY OF *SMILODON* DURING GLACIAL AND INTERGLACIAL PERIODS OF THE PLEISTOCENE

**WEDNESDAY MORNING, OCTOBER 18, 2023**
**TECHNICAL SESSION 3: FISHES & AMPHIBIANS**
**MEETING ROOM JUNIOR BALLROOM D**
**MODERATORS: Zerina Johanson and Jamey Creighton**

**8:00** **X. Liu**, **M. Zhu**, **J. Lu** THE STEM OSTEICHTHYAN *ACHOANIA* FROM CHINA SHEDS LIGHT ON THE COMPLEX PATTERN OF PARASPHENOID IN CROWN GNATHOSTOMES

**8:15** **Y. Zhu**, **J. Lu**, **P. Ahlberg**, **M. Zhu** A COMPLETELY PRESERVED EARLY SILURIAN BONY FISH REVEALS THE MOSAIC CHARACTER COMBINATION IN THE STEM-GROUP OSTEICHTHYAN

**8:30** **C.D. Brownstein** A GIANT RAPTORIAL BOWFIN (OSTEICHTHYES: HALECOMORPHI) FROM THE PALEOGENE OF NORTH AMERICA

**8:45** **J.A. Long**, **A. Fitzpatrick**, **T. Dixon**, **A. Clement** NEW ANATOMICAL INFORMATION ON THE PLACODERM FISH *GROENLANDASPIS*

**9:00** **N. Sharma**, **Y. Haridy**, **N. Shubin** PECTORAL JOINT OF DEVONIAN ANTIARCH FISHES PRODUCED STRIDULATING SOUNDS

**9:15** **D.M. Leong**, **J. Liu** COMPARISON OF THE LATERAL LINE TUBULES OF TETRAPODOMORPHS FROM THE RED HILL LOCALITIES OF NEVADA AND PENNSYLVANIA

**9:30** **Z. Johanson**, **J. Leyhr**, **T. Challands**, **A. Violaris**, **S. Sanchez**, **K. Dollman**, **M. Smith** BONE REPAIR IN THE DEVONIAN LUNGFISH *DIPTERUS VALENCIENNESI* AFTER INJURY

**9:45** **Y. Haridy**, **K. Nanglu**, **N. Sharma**, **S. Norris**, **J. Ortega-Hernandez**, **N. Shubin** TOOTH ORIGINS AND THE CONVERGENT EVOLUTION OF SENSORY STRUCTURES

**10:15** **D. Falk**, **O. Wings**, **M.E. McNamara** ANURAN TAPHONOMY AS FOUNDATION FOR A NEW TAPHONOMIC MODEL FOR THE EOCENE GEISELTAL KONSERVAT-LAGERSTÄTTE (GERMANY)

**10:30** **V. Rossi**, **A. O'Gogain**, **R. Unitt**, **M.E. McNamara** SYNCHROTRON-XRF AND VIBRATIONAL SPECTROSCOPY REVEAL SOFT TISSUES IN THE HORNED TETRAPOD *KERATERPETON* (PENNSYLVANIAN, JARROW, IRELAND)

**10:45** **B. Igielman**, **J. Head**, **R.B. Benson** A PHYLOGENETIC RE-EXAMINATION OF LEPOSPONDYLII; IMPLICATIONS FOR CROWN TETRAPOD DIVERGENCE TIMES AND THE ORIGIN OF AMNIOTES

**11:00** **Z. Xiong**, **A. Mann**, **H.C. Maddin** DESCRIPTION OF A NEW SPECIES OF PANTYLID “MICROSAUR” FROM THE CARBONIFEROUS OF NOVA SCOTIA AND IMPLICATIONS FOR ITS ECOLOGY

**11:15** **J. Creighton**, **J. Anderson** MORPHOLOGICAL ANALYSIS OF A NECTRIDEAN LEPOSPONDYL, *DICERATOSAURUS*, FROM LINTON AND FIVE POINTS, OHIO.

**11:30** **A.M. Kufner**, **O.H. Blomberg**, **H.M. Gonzales**, **D.M. Lovelace** SPECIMEN-LEVEL ASSESSMENT OF ONTOGENY AND PHYLOGENY OF NORTH AMERICAN METOPOSAURIDS (TETRAPODA, TEMNOSPONDYLI)

**11:45** **C. So**, **I. Wilenzik**, **A. Mann** HIDDEN BIOGEOGRAPHY: THE IMPACT OF CONTINENTAL DRIFT ON THE TEMPORAL AND SPATIAL DISTRIBUTION AND EVOLUTION OF TEMNOSPONDYLS

**12:00** **D. Marjanović** TETRAPODOMORPH PHYLOGENY INCLUDING THE ORIGINS OF LISSAMPHIBIA AND AMNIOTA: GO BIG OR GO HOME

**WEDNESDAY AFTERNOON, OCTOBER 18, 2023**
**TECHNICAL SESSION 4: DINOSAUR SOFT TISSUES**
**MEETING ROOM JUNIOR BALLROOM A/B**
**MODERATORS: Annie McIntosh and John Fortner**

**1:45** **P.J. Byrne**, **N.D. Smith**, **R. Irmis**, **A. Huttenlocker** VERTEBRAL MORPHOLOGY AND HISTOLOGIC CORRELATES OF CARDIOPULMONARY EVOLUTION IN TERRESTRIAL AND AQUATIC ARCHOSAURIA: CASE STUDY OF A SECONDARILY AQUATIC BIRD *AECHMOPHORUS*

**2:00** **A.C. Morhardt**, **A. Nabavizadeh** SYSTEMATIC REVIEW OF EVIDENCE FOR AND AGAINST THE PRESENCE OF EXTRAORAL TISSUES IN NON-AVIAN DINOSAURS

**2:15** **C.A. Boyd**, **S.K. Drumheller**, **M. Householder**, **B. Saini-Eidukat**, **J. Nestler**, **P. Ullmann** GEOCHEMICAL EXAMINATION OF DINOSAURIAN "MUMMIES" FROM THE HELL CREEK FORMATION REVEALS A PATHWAY FOR DERMAL TISSUE FOSSILIZATION

**2:30** **T. Joubarne**, **F. Therrien**, **D.K. Zelenitsky** INTEGUMENTARY IMPRESSIONS ON HADROSAURID SPECIMENS FROM THE UPPER CRETACEOUS (UPPER CAMPANIAN) DINOSAUR PARK FORMATION, ALBERTA, CANADA REVEAL GREAT DIVERSITY IN INTEGUMENT PATTERNS AND MANUAL SOFT-TISSUE MORPHOLOGY

**2:45** **D.G. Cerio**, **G.S. Bever**, **L.M. Witmer** THE HADROSAUR POSTORBITAL "POCKET" AND THE EVOLUTION OF EXTRARENAL SALT-EXCRETION IN REPTILIA

**3:00** **J.Z. Wasserlauf**, **J. Mallon**, **T. Cullen**, **F. Therrien**, **B. Cousens**, **C. Bataille** ISOTOPE PALEOECOLOGY OF DUCK-BILLED DINOSAURS (ORNITHISCHIA: HADROSAURIDAE) FROM THE UPPER CAMPANIAN DINOSAUR PARK FORMATION

**3:15** **J.P. Garderes**, **J.A. Whitlock**, **N. Toledo**, **P.A. Gallina** SEEMINGLY MOODY: A HYPOTHETICAL RECONSTRUCTION OF THE EYE MUSCULATURE OF *BAJADASAURUS*

**3:30** **Z. Yang**, **B. Jiang**, **M.E. McNamara** THREE-DIMENSIONAL PRESERVATION OF SKIN ULTRASTRUCTURE IN A FEATHERED DINOSAUR

**3:45** **J.D. Fortner**, **K. Sellers**, **C. Holliday** NON-AVIAN THEROPODS DID NOT HAVE LATERALLY-WRAPPING PTERYGOIDEUS MUSCLES

**4:00** **A. McIntosh**, **C. Sullivan**, **J. Acorn**, **P.J. Currie** INSIGHTS AND LIMITATIONS IN RECONSTRUCTING THE MUSCULATURE AND SKELETAL ARRANGEMENT OF THE FOOT IN TYRANNOSAURIDS AND OTHER NON-AVIAN THEROPOD DINOSAURS

**WEDNESDAY AFTERNOON, OCTOBER 18, 2023**
**TECHNICAL SESSION 5: UNGULATES**
**MEETING ROOM JUNIOR BALLROOM C**
**MODERATORS: Russel Engelman and Bin Bai**

**1:45** **G.F. Funston**, **S. Holpin**, **S. Shelley**, **T. Williamson**, **S. Brusatte** EVIDENCE OF DISPARATE LIFE HISTORIES IN THE PALAEOCENE RISE OF EUTHERIA

**2:00** **J.S. Silviria**, **G. Wilson Mantilla** A PRELIMINARY SYSTEMATIC ASSESSMENT OF EARLIEST PALEOCENE NORTH AMERICAN "ARCHAIC UNGULATES" USING GEOMETRIC MORPHOMETRIC DATA FROM POSTCANINE DENTITION

**2:15** **R. Engelman**, **R.M. Beck**, **P. Potts**, **D.A. Croft** NO SUPPORT FOR AN INTERCHANGE-DRIVEN EXTINCTION OF NOTOUNGULATES AND LITOPTERNS BASED ON DIVERSIFICATION RATES OF SOUTH AMERICAN NATIVE UNGULATES (SANUS)

**2:30** **B. Bai**, **Y. Wang**, **J. Theodor**, **J. Meng** DIVERSE ARTIODACTYLS FROM THE MIDDLE EOCENE OF THE ERLIAN BASIN, INNER MONGOLIA, CHINA

**2:45** **A. Wimberly** USING BAYESIAN MULTI-LEVEL MODELING TO PREDICT HABITAT IMPORTANCE IN RUMINANTIA

**3:00** **S. Robson**, **J. Theodor** BASAL CAMELIDS: AUDITORY REGION MORPHOLOGY AND PHYLOGENETIC IMPLICATIONS

**3:15** **K. O'Brien**, **K. Podkovyroff**, **D.P. Fernandez**, **C. Tryon**, **L. Ashioya**, **T.E. Cerling**, **J. Faith** ISOTOPIC EVIDENCE OF SEASONALITY AND MIGRATION DURING THE LAST GLACIAL PERIOD OF KENYA

**3:30** **A. Grossman**, **V. Waweru**, **N.R. Malit**, **S. munge**, **F. Ndiritu**, **C. Omuombo**, **R. Kinyanjui**, **L. Chege**, **R. Kinyua**, **F.M. Kirera** GIANT EXTINCT BOVIDS FROM THE PLEISTOCENE OF THE CENTRAL HIGHLANDS OF KENYA

**3:45** **F.M. Kirera**, **C. Omuombo**, **N.R. Malit**, **V. Waweru**, **R. Kinyanjui**, **L. Chege**, **R. Kinyua**, **F. Ndiritu**, **S. munge**, **A. Grossman** A NEW SPECIES OF ANTILOPINI FROM THE PLEISTOCENE OF THE CENTRAL HIGHLANDS, KENYA

**4:00** **M. Gaetano**, **J.H. Miller**, **E. Wald**, **P.S. Druckenmiller** GROUNDS FOR COMPARISON: SPATIAL TRENDS IN THE UTILIZATION OF SHED CARIBOU ANTLERS AS MINERAL RESERVES

**WEDNESDAY AFTERNOON, OCTOBER 18, 2023**
**TECHNICAL SESSION 6: MARINE REPTILES**
**MEETING ROOM JUNIOR BALLROOM D**
**MODERATORS: Jun Liu and Yu Qiao**

**1:45** **J. Liu**, **A.S. WOLNIEWICZ**, **Q. Li**, **Y. Qiao**, **Y. Hu** AN ARMORED MARINE REPTILE FROM THE EARLY TRIASSIC OF SOUTH CHINA WITH IMPLICATIONS FOR THE PHYLOGENY OF ARCHELOSAURIA

**2:00** **Y. Qiao**, **R. Motani**, **M. Iijima**, **J. Liu** A NEW HUPEHSUCHIAN (REPTILIA: ICHTHYOSAUROMORPHA) FROM THE LOWER TRIASSIC OF SOUTH CHINA SHOWING CONVERGENT EVOLUTION OF POLYDACTYLY

**2:15** **R.O. Clark**, **F.R. O'Keefe** A REVISION OF THE GENUS *DOLICHORHYNCHOPS* WITH IMPLICATIONS FOR THE EVOLUTION AND BIOGEOGRAPHY OF POLYCOTYLIDAE

**2:30** **WITHDRAWN**

**2:45** **Y. Hu**, **Q. Li**, **J. Liu** A NEW PACHYPLEUROSAUR (REPTILIA: SAUROPTERYGIA) FROM THE MIDDLE TRIASSIC OF SOUTHWESTERN CHINA

**3:00** **F.R. O'Keefe**, **E. Armour Smith**, **N. Caroll**, **S. Moore**, **E. Lamm** HISTOLOGY AND PALEOPATHOLOGY OF A NEW ELASMOSAUR SKELETON FROM THE PIERRE SHALE OF SOUTHEASTERN MONTANA

**3:15** **G. McGaughey**, **R. Irmis**, **N. Kelley**, **S. Howard**, **N. Fasig**, **P. Noble** THE LAST TRIASSIC GIANT? A LATE RHAETIAN ICHTHYOSAUR FROM NEW YORK CANYON, NEVADA, USA

**3:30** **T. Konishi**, **M. Ohara**, **A. Misaki**, **H. Matsuoka**, **H. Street** A NEW DERIVED MOSASAURINE (SQUAMATA: MOSASAURIDAE) FROM SOUTHWESTERN JAPAN REVEALS UNEXPECTED POSTCRANIAL DIVERSITY AMONG FLIPPER-BEARING MOSASAURS

**3:45** **N. Kelley**, **D. Bastiaans**, **P.S. Druckenmiller**, **N. Klein**, **J. Liu**, **E.T. Metz**, **M. Sander**, **T. Scheyer** DIVERGENT EVOLUTIONARY TRAJECTORIES OF THALATTOSAUROID AND ASKEPTOSAUROID THALATTOSAURS (DIAPSIDA: THALATTOSAURIA)

**4:00** **T. Denham**, **J.M. White**, **V. Fischer**, **M. McCurry** TOOTH SHAPE IN MESOZOIC MARINE REPTILES

**WEDNESDAY – SATURDAY, OCTOBER 18-21, 2023**
**COLBERT PRIZE POSTER SESSION**
**MEETING ROOM GRAND BALLROOM B**
**Authors must be present from 4:30 – 6:30 p.m. on Wednesday, October 18**

**B1** **L.S. Snyderman**, **A. Spiess**, **O.L. Olson**, **S. Turvey**, **A.M. Mychajliw** SPATIOTEMPORAL DYNAMICS OF QUATERNARY RANGE COLLAPSE OF THE GREAT AUK (*PINGUINUS IMPENNIS*): NEW INSIGHTS FROM THE GULF OF MAINE

**B2** **D.R. Pittinger**, **H.A. Lott**, **E.L. Simpson**, **G. Zinati**, **D. Aruscavage**, **G. Rogers**, **J. Cook**, **D. Reyes**, **J. Scherer** NEOTAPHONOMIC ANALYSIS OF GALLOANSERAE EGGS: A MODERN ANALOG FOR THE PRESERVATION OF DINOSAUR EGGS

**B3** **A. Gardiner**, **R. Cooper**, **K. Kocáková**, **J. Villafaña**, **C. Pimiento**, **D. Silvestro** NEOSELACHIAN DIVERSITY THROUGH DEEP TIME

**B4** **S.L. Garcia-Lara**, **Z. Tseng** LOOKING FOR THE ROLE OF HYPSODONTY IN THE MANDIBULAR BIOMECHANICS OF THE OREDONTS (ARTIODACTYLA, MERYCOIDODONTIDAE)

**B5** **E. Bogner**, **J. Meachen**, **Z. Tseng** BIOMECHANICAL ANALYSIS OF *SMILODON* FORELIMBS REVEALS UNIQUE ADAPTATIONS FOR PREY ACQUSITION AND PROCESSING

**B6** **I.M. Gomez**, **X. Wang**, **S. Johnson**, **A. Rogers**, **R. Hulbert**, **L. DeSantis** TO SEA OR NOT TO SEA: DIETARY ECOLOGY OF *ENHYDRITHERIUM TERRAENOVAE* AS INFERRED FROM DENTAL MICROWEAR TEXTURE ANALYSIS

**B7** **Z. Guo**, **N. Kohno** HEARING ABILITIES AS DRIVERS OF EVOLUTION AND DIVERSIFICATION OF THE DELPHINIDA

**B8** **J.R. Baez**, **M.F. Jones**, **N.S. Upham** REFINING FOSSIL BAT OCCURRENCE AGES TO STUDY RATES OF SPECIES DIVERSIFICATION NEAR THE EARLY EOCENE CLIMATIC OPTIMUM

B9 **J. Schap**, **J. Meachen**, **J.L. McGuire** CHANGES IN SMALL MAMMAL COMMUNITIES OVER THE LAST 25,000 YEARS SHOW A COMPLEX RELATIONSHIP BETWEEN COMPOSITION, TRAITS, AND ARIDITY

**-WITHDRAWN-**

**B10** **R.S. Paterson**, **M. Mackie**, **I. Patramanis**, **A. Strange**, **D. Fraser**, **N. Rybczynski**, **R. MacPhee**, **F. Demeter**, **E. Cappellini** DENTAL ENAMEL PROTEOMES FROM THE HOLOCENE THROUGH TO THE EARLY MIOCENE REVEAL PATTERNS OF ANCIENT PROTEIN PRESERVATION AND DEGRADATION

**B11** **K. Miller**, **K. Beard** NEW PALEOCENE METATHERIAN FROM THE TIFFANIAN OF BIG BEND NATIONAL PARK, TEXAS AND ITS RELATIONSHIP TO OTHER LATE CRETACEOUS AND EARLY PALEOGENE METATHERIANS

**B12** **D.M. Peltier**, **J.K. Njau** QUANTIFYING GEOGRAPHIC AND TEMPORAL DISTRIBUTION OF VERTEBRATE FAUNA DURING BED II TIMES AT OLDUVAI GORGE, TANZANIA

**B13** **I.T. McKinney**, **C. Griffin**, **S.J. Nesbitt** WHAT IS THE ONTOGENETIC AGE OF EARLY DINOSAURS AND THEIR CLOSE RELATIVES? A SURVEY OF ONTOGENETIC AGES THROUGH HISTOLOGICAL DATA

**B14** **H.J. Allen**, **D.J. Varricchio** A NEW DIMINUTIVE HETERODONT CROCODYLIFORM FROM THE ALBIAN-CENOMANIAN BLACKLEAF FORMATION OF SOUTHWEST MONTANA

**B15** **D.R. Leaphart**, **S.E. Pierce**, **C.A. Brochu** PHYLOGENETIC RELATIONSHIPS OF A NEW SMALL NEOSUCHIAN CROCODYLIFORM FROM THE EARLY CRETACEOUS CLOVERLY FORMATION OF MONTANA

**B16** **H.S. Sharpe**, **T. Dudgeon** AN ENTHESEAL ORIGIN FOR THE HADROSAUR (ORNITHISCHIA: HADROSAURIDAE) JUGAL FLANGE

**B17** **M. Son**, **P. Makovicky**, **Y. Lee**, **H. Kim**, **I. Paik**, **S. Jung**, **D. Kong**, **S. Lee**, **H. Yoon** A CERATOPSIAN MANDIBLE FROM THE ‘MID’-CRETACEOUS OF SOUTH KOREA

**B18** **J. Kramer**, **J. Stephens**, **M. Wosik** INTEGRATING SECOND MOMENT OF AREA WITH OSTEOHISTOLOGY TO IDENTIFY LIMITATIONS OF WEIGHT-BEARING LIMB BONES

**B19** **J. Hedge**, **E.R. Bender**, **L.E. Zanno** ORIENTATION: A NEW R FUNCTION FOR QUANTIFYING THE DIRECTION AND STRENGTH OF ORIENTATION ON PALEONTOLOGICAL SURFACES AND ITS APPLICATION TO THE EGGS OF OVIRAPTOROSAURIA

**B20** **J.L. Pinto**, **A. Huttenlocker**, **S.J. Nesbitt**, **M. Fabbri**, **N. Ibrahim**, **C. Marshall** “SAILBACKS” THROUGH DEEP TIME: A COMPARATIVE OSTEOHISTOLOGICAL ANALYSIS OF HYPERELONGATE NEURAL SPINES IN *ARIZONASAURUS BABBITTI* AND OTHER AMNIOTES

**B21** **S. Tada**, **T. Tsuihiji**, **L.M. Witmer** MORPHOGENETIC MECHANISMS UNDERLYING THE CRANIAL EVOLUTION OF PSEUDOSUCHIANS: COMPARISONS OF EVOLUTIONARY AND DEVELOPMENTAL CHANGES IN SKULL SHAPE

**B22** **A.F. Alfonso Rojas**, **J.D. Carrillo-Briceño**, **R. Sánchez**, **M.R. Sanchez-Villagra**, **J.J. Head** AN EARLY ORIGIN OF GIGANTISM IN ANACONDAS (SERPENTES: *EUNECTES*) REVEALED BY THE FOSSIL RECORD

**B23** **D.E. Korneisel**, **H.C. Maddin** EVOLUTION OF THE TETRAPOD ATLAS-AXIS COMPLEX

**B24** **E.C. Watt**, **R. Felice**, **A. Goswami** EVOLUTIONARY PATTERNS OF SIMPLIFICATION AND DIVERSIFICATION IN THE TETRAPOD LOWER JAW

**WEDNESDAY – SATURDAY, OCTOBER 18-21, 2023**
**2020-2022 GRAFF AWARD POSTER SESSION**
**MEETING ROOM GRAND BALLROOM B**
**Authors must be present from 4:30 – 6:30 p.m. on Wednesday, October 18**

**B25** **M. Zondo**, **J. Choiniere**, **P. Barrett** BIOSTRATIGRAPHIC CORRELATION OF UPPER KAROO-AGE FOSSILS FROM THE MPANDI FORMATION OF SENTINEL RANCH, TULI BASIN, ZIMBABWE

**B26** **A.S. Gohar**, **M.S. Antar**, **S. El-Sayed**, **H.M. Sallam** FROZEN IN TIME: UNIQUELY PRESERVED PROTOCETID WHALE ENTOMBED INSIDE DECORATIVE LIMESTONE FROM THE MIDDLE EOCENE OF EGYPT

**B27** **M.U. Tablizo**, **G.D. van den Bergh**, **A.S. Fernando** REVISITING THE *STEGODON* OF LUZON, PHILIPPINES – INSIGHTS FROM NEW FOSSIL MATERIAL

**WEDNESDAY AFTERNOON, OCTOBER 18, 2023**
**PALEONTOLOGICAL MANAGEMENT POSTER SESSION**
**MEETING ROOM GRAND BALLROOM B**
**Authors must be present from 4:30 – 6:30 p.m. on Wednesday, October 18**

**B28** **C.R. Dunn**, **J.J. El Adli** THIS IS NO CAVE: PROACTIVE INVENTORY OF THE PLIO-PLEISTOCENE CAMP RICE FORMATION IN ORGAN MOUNTAINS-DESERT PEAKS NATIONAL MONUMENT, NEW MEXICO

**B29** **L.T. Yann** THE MAMMOTH IN THE ROOM: PALEONTOLOGICAL RESOURCES AND NON-FEDERAL PARTNERSHIPS AT WACO MAMMOTH NATIONAL MONUMENT

**B30** **A.W. Kellner** RECOMPOE - AN INITIATIVE TO OBTAIN ORIGINAL ITEMS FOR THE EXHIBITIONS OF THE MUSEU NACIONAL/UFRJ

**B31** **P.C. Murphey**, **G.E. Knauss**, **T.A. Demere**, **D. Spivak**, **K. Moreno**, **K. McComas** BEST PRACTICE GUIDELINES FOR MITIGATION OF ADVERSE IMPACTS TO PALEONTOLOGICAL RESOURCES

**B32** **D.E. Wagner**, **W.G. Parker**, **M.E. Smith**, **P.J. Varela**, **D. Boudreau** DEVELOPMENT OF A MULTIFUNCTIONAL FOSSIL PREPARATION FACILITY IN SUPPORT OF PALEONTOLOGICAL RESOURCE MANAGEMENT AND SCIENCE AT PETRIFIED FOREST NATIONAL PARK, ARIZONA (USA)

**B33** **J. Tweet**, **V. Santucci** HOW PROTECTING SHARKS CAN LEAD TO FINDING DOLPHINS: GEORGE WASHINGTON BIRTHPLACE NATIONAL MONUMENT AS A CASE STUDY IN DEVELOPING AND IMPLEMENTING PALEONTOLOGICAL RESOURCE MONITORING

**B34** **C.J. Salcido**, **P.J. Wilson**, **J. Tweet**, **B. McCann**, **C.A. Boyd**, **V. Santucci** A PALEONTOLOGICAL RESOURCE INVENTORY OF THEODORE ROOSEVELT NATIONAL PARK REVEALS POTENTIAL FOR FUTURE VERTEBRATE PALEONTOLOGICAL RESEARCH AND MANAGEMENT

**B35** **W.G. Parker**, **M.E. Smith**, **A. Marsh** BUILDING A TRIASSIC PARK: FORMULATING A CREDIBLE SCIENTIFIC RESEARCH AND OUTREACH PROGRAM FOR PALEONTOLOGY IN A U.S. NATIONAL PARK

**B36** **C. Eaton**, **B.H. Breithaupt**, **J. Krishna**, **K. MacKenzie**, **K. Prassack**, **A.N. Rountrey**, **V. Santucci**, **B. Schumacher**, **G.A. Liggett** CASE STUDIES IN THE MANAGEMENT OF FEDERAL PALEONTOLOGICAL COLLECTIONS AND RECOMMENDATIONS FOR THE FUTURE

**B37** **D. Boudreau**, **A.D. Marsh**, **M.E. Smith** ADVANCING FEDERAL PALEONTOLOGY MANAGEMENT THROUGH INTRA-AGENCY COLLABORATION IN THE NATIONAL PARK SERVICE

**B38** **T. Tran** PALEONTOLOGICAL INVENTORY AT BRYCE CANYON NATIONAL PARK, UTAH RECOVERS LATE CRETACEOUS VERTEBRATE DIVERSITY AND POTENTIAL FOR RESOURCES MANAGEMENT AND FUTURE RESEARCH

**B39** **R.K. Hunt-Foster**, **B.H. Breithaupt** CAN YOU HEAR ME NOW? HAVING YOUR VOICE HEARD ON PALEONTOLOGICAL ISSUES THROUGH PUBLIC COMMENT PERIODS

**B40** **R. Colvin**, **R.K. Hunt-Foster** PROACTIVELY INCREASING PUBLIC AWARENESS ABOUT THE SIGNIFICANCE OF PALEONTOOLOGICAL RESOURCES ALONG THE FOSSIL DISCOVERY TRAIL IN DINOSAUR NATIONAL MONUMENT

**B41** **A.S. Schulp**, **I. Eijkelboom**, **J.W. Reumer** CITIZEN SCIENCE AND PROFESSIONAL PALEONTOLOGY: THE DUTCH EXAMPLE

**B42** **V. Santucci**, **J. Tweet**, **J.M. Hodnet**, **C. Visaggi** U.S. NATIONAL PARK SERVICE PALEONTOLOGICAL RESOURCE INVENTORY AND MONITORING SUPPORTS STEWARDSHIP, SCIENCE AND DISCOVERY OF NON-RENEWABLE FOSSIL IN PARKS

**B43** **R.E. Narducci**, **J.I. Bloch**, **R. Hulbert**, **S.P. Zbinden** HUNTING FOR FOSSILS IN THE SUNSHINE STATE: MODERNIZING THE FLORIDA FOSSIL PERMIT PROGRAM

**B44** **W.J. Wilkins**, **B. Schumacher**, **T. Love**, **R. Hewitt**, **D. Lennox**, **H. Russon**, **E. Skeans** REINVENTING THE UNITED STATES FOREST SERVICE PALEONTOLOGY GEODATABASE

**B45** **A. Marsh**, **C.V. Beightol**, **N.G. Toth**, **B.T. Kligman**, **W.G. Parker** SYSTEMATIC PALEONTOLOGICAL INVENTORY OF NEWLY ACQUIRED LANDS AT PETRIFIED FOREST NATIONAL PARK REVEALS UNPRECEDENTED DIVERSITY OF LATE TRIASSIC TERRESTRIAL VERTEBRATES

**B46** **D.D. DeBlieux**, **J.I. Kirkland**, **M. Hayden**, **R. Fasselin**, **M. Jensen**, **Z. Anderson**, **B. Sears** THE UTAH STATE PALEONTOLOGICAL LOCALIYTY DATABASE - USING COMPUTER TABLET APPLICTIONS FOR THE COLLECTION AND COMPILATION OF PALEONTOLOGICAL LOCALITY DATA

**B47** **G.A. Liggett** A NEW TYPE OF RAPTOR: RECREATION AND PERMIT TRACKING ONLINE REPORTING

**B48** **M.K. Macias**, **C. Shi**, **A.L. Ollendorf** TO SCREEN OR NOT TO SCREEN: COMPREHENSIVE MITIGATION MEASURES FOR CONSTRUCTION PROJECTS

**B49** **D.M. Lovelace**, **A. LeClair-Diaz**, **A.M. Kufner**, **C. So**, **A. Fitch**, **H. Woznkick**, **E. Parrish**, **M.R. Acosta** WHAT'S IN A NAME? PUTTING DECOLONIZATION OF SCIENTIFIC NOMENCLATURE INTO PRACTICE THROUGH LOCAL COMMUNITY PARTNERSHIPS

**B50** **D.C. Pagnac** THE WESTERN INTERIOR SEAWAY BY FLAT-BOTTOMED BOAT: SURVEY AND SALVAGE OF US ARMY CORPS OF ENGINEERS LAND IN SOUTH DAKOTA, USA

**B51** **J. Hopkins**, **M.G. Price**, **N. Toth**, **S. Bastien**, **H. Petermann**, **B. Schumacher** RE-PREPARATION AND PRESERVATION REVEALS NEW INSIGHTS INTO A UNIQUE SAUROPOD BONEBED (MORRISON FM, COMANCHE NATIONAL GRASSLAND, COLORADO)

**B52** **R.J. Gay**, **L. Krumenacker**, **B.R. Peecook** WAYAN'S WORLD: DIGITIZING (MOST OF) A STATE'S CRETACEOUS FOSSIL RECORD

**B53** **B.H. Breithaupt**, **N.A. Matthews**, **T. Noble** THE PHOTOGRAMMETRIC REVOLUTION: TWENTY-FIVE YEARS OF PHOTOGRAMMETRY FOR PRESERVATION AND MANAGEMENT OF PALEONTOLOGICAL RESOURCES (1998-2023): PRESERVING ANCIENT ECOSYSTEMS AND AMERICA'S NATURAL HERITAGE

**WEDNESDAY AFTERNOON, OCTOBER 18, 2023**
**REGULAR POSTER SESSION 1**
**MEETING ROOM GRAND BALLROOM B**
**Authors must be present from 4:30 – 6:30 p.m. on Wednesday, October 18**

**B54** **P.L. Larson** PRESERVING FOSSIL RESOURCES: AN ELEGANT SOLUTION FOR THE PUBLIC AND PRIVATE SECTOR

**B55** **A.N. Coultley**, **E.B. Davis**, **P. Ward** FLYING HIGH: A NEW SPECIES OF *DIOMEDEA* (AVES, DIOMEDEIDAE) AND IMPLICATIONS FOR THE PALEOECOLOGY OF THE PACIFIC NORTHWEST MIOCENE

**B56** **E.J. Cruz Vega**, **J. O'Connor**, **J.J. Sertich** WELL-PRESERVED CROWN BIRD SYNSACRUM FROM THE LATEST CRETACEOUS HELL CREEK FORMATION OF SOUTH DAKOTA, U.S.A.

**B57** **C. Cooper**, **M. Fabbri**, **J. O'Connor** THE OSTEOHISTOLOGY OF *BAPTORNIS*

**B58** **T. Hieronymus**, **P.M. O'Connor**, **C. Mtelela**, **E.M. Roberts**, **N.J. Stevens** AVIFAUNA FROM THE NSUNGWE FORMATION (LATE OLIGOCENE) OF THE RUKWA RIFT BASIN, EASTERN AFRICA

**B59** **A.K. Hunt**, **O. Plateau**, **J. Benito**, **L. Fisher**, **D.J. Field** MICRO-COMPUTED TOMOGRAPHY CASTS NEW LIGHT ON THE PROCESS OF PTERYGOID SEGMENTATION IN THE PALATES OF JUVENILE NEOGNATHOUS BIRDS.

**B60** **J. Benoit** SENSORY ORGANS AND PALAEOBIOLOGY OF CYNODONTS

**B61** **H. Simon**, **M. Donnell**, **L. Stancik**, **E. Vollmer**, **C. Flis** TROPHIC ECOLOGY AND TAPHONOMY OF THE LOWER PERMIAN CRADDOCK BONE BED USING QUANTITATIVE ANALYSIS OF ASSOCIATED DIMETRODON SKELETONS.

**B62** **D. Rowe**, **B. Boyd**, **J. Bevitt**, **R. Reisz** NEUTRON TOMOGRAPHY PROVIDES NEW INFORMATION ON THE FOOT MORPHOLOGY OF THE EARLY PERMIAN VARANOPID *MESENOSAURUS EFREMOVI*

**B63** **J. Bevitt**, **R. Reisz**, **T. Maho** DENTAL ANATOMY, DEVELOPMENT, REPLACEMENT, AND THE EVOLUTION OF MAMMALIAN FEATURES AS EVIDENCED BY THE LATE PERMIAN ANOMODONT *SUMINIA*

**B64** **K.M. Jenkins**, **C.M. Gordon**, **B.S. Bhullar** CHANGES IN THE PARIETAL FORAMEN TRACK MAJOR EVENTS IN AMNIOTE EVOLUTION

**B65** **I. Eijkelboom**, **A.S. Schulp**, **L. Hogeweg**, **N. den Ouden**, **F. Wesselingh** LEGASEA: AI IMAGE RECOGNITION AND CITIZEN SCIENCE HELP CONTEXTUALIZE EX SITU QUATERNARY FOSSILS FROM THE DUTCH NORTH SEA

**B66** **A. Khan**, **A. Rafeh**, **R. Ahmad** MIDDLE MIOCENE UNGULATES FROM THE SIWALIK HILLS OF PAKISTAN: SYSTEMATIC AND BIOGEOGRAPHIC IMPLICATIONS

**B67** **A. Lang** FUNCTIONAL MORPHOLOGY OF CARNASSIAL DENTITIONS IN CARNIVOROUS MAMMALS (CARNIVORA, HYAENODONTA, DASYUROMORPHIA)

**B68** **M. Ameen**, **F. Irshad**, **A. Khan**, **S.G. Abbas** MAMMALIAN REMAINS FROM THE MIDDLE MIOCENE DEPOSITS OF DHOK BUN AMEER KHATOON, PUNJAB, PAKISTAN

**B69** **A. Rogers**, **S. Johnson**, **L. DeSantis** DIETARY ECOLOGY OF EXTANT MARINE MAMMALS CAN BE INFERRED FROM DENTAL MICROWEAR TEXTURE ANALYSIS

**B70** **L.E. Lopes**, **P.A. Holroyd**, **H. Ro**, **J. Southon**, **S. Kim**, **R. Trayler** RAPID SCREENING OF TAR SEEP FOSSILS FOR RADIOCARBON AND STABLE ISOTOPE ANALYSIS

**B71** **L.W. Viñola-López**, **J. Almonte**, **A. Luthra**, **J.I. Bloch** A NEW *SOLENODON* AND HUTIA FROM THE LATE QUATERNARY OF HISPANIOLA

**B72** **B.E. Connelly**, **M.S. Cardozo**, **J.D. Montgomery**, **G.W. Rougier** NEW MAMMALS FROM THE LATE CRETACEOUS FROM ALLEN FORMATION (PATAGONIA, ARGENTINA) AND THE RISE OF MERIDIOLESTID DENTAL DIVERSITY

**B73** **M.E. Hunt**, **M.P. Ball**, **A. Claxton**, **R.A. Martin**, **E. Jimenez-Hidalgo**, **J.J. Calède** CONTRASTING BODY SIZE EVOLUTION IN ENTOPTYCHINE AND GEOMYINE GOPHERS (RODENTIA, GEOMYIDAE)

**B74** **I.R. Newbins**, **S.T. Lavin**, **G. Wilson Mantilla** NEW SAMPLES OF LATE CRETACEOUS (JUDITHIAN) MULTITUBERCULATE MAMMALS FROM THE JUDITH RIVER FORMATION OF HILL COUNTY, MONTANA

**B75** **K.B. Townsend**, **L. Stroik**, **E. Miller**, **P.C. Murphey**, **A. Friscia**, **P. Higgins** SCREENWASHING THE MECO: RECOVERING MICROVERTEBRATES FROM THE DUCHESNE RIVER FORMATION, UINTA BASIN, UTAH

**B76** **Z. Xu**, **J.X. Samuels** EARLY PLIOCENE MICE AND RATS FROM THE GRAY FOSSIL SITE OF EASTERN TENNESSEE

**B77** **B.T. Hovatter**, **G. Wilson Mantilla** NEW EARLY TORREJONIAN (TO1) MAMMALS FROM NORTHEASTERN MONTANA, U.S.A.

**B78** **M.H. Haji-Sheikh**, **V.L. Naples**, **M. Haji-Sheikh** ABRASION IS THE PITS: A STUDY OF UNIQUE DAMANGE AT RANCHO LA BREA

**B79** **X. Munoz**, **J.J. Eberle**, **G.M. Erickson**, **P.S. Druckenmiller** HIDDEN MAMMALIAN DIVERSITY REVEALED BY EDENTULOUS JAWS FROM THE UPPER CRETACEOUS (LATE CAMPANIAN) PRINCE CREEK FORMATION OF NORTHERN ALASKA

**B80** **B.B. Wooten** HEMPHILLIAN GRASSLAND ECOSYSTEMS: REVISITING DATA FROM THE MINIUM QUARRY (OGALLALA FORMATION) IN GRAHAM COUNTY, KANSAS

**B81** **A.M. Dunne**, **J. Jacisin**, **J.R. Moore** A DESCRIPTION OF A NEW CHADRONIAN VERTEBRATE MICROSITE FROM THE WHITE RIVER GROUP OF NEBRASKA, U.S.A.

**B82** **R. Secord** THE PALEOCENE-EOCENE THERMAL MAXIMUM IN THE TOGWOTEE PASS AREA, WYOMING, USA

**B83** **A.A. Rock**, **W. Godwin**, **P.J. Lewis** IDENTIFICATION OF THE PUSH CREEK FAUNA, A MIOCENE FAUNA FROM EAST TEXAS

**B84** **J.I. Herold**, **W. Lukens**, **J.B. Rossie**, **S.M. Cote**, **D.J. Peppe**, **A.L. Deino** PALEOENVIRONMENTAL RECONSTRUCTION OF A MIDDLE MIOCENE HOMINOID FOSSIL SITE IN WEST TURKANA, KENYA

**B85** **E.T. Saitta**, **H. Latta**, **J. Vinther**, **T. Gnoske**, **T.G. Kaye**, **R. Brooker**, **I.D. Bull**, **P.C. Sereno** SEXING DINOSAURS: POSSIBLE DETECTION OF TRACE SEX HORMONES IN FOSSILS AS OLD AS THE JURASSIC AND THE THERMAL STABILITY OF ESTROGEN

**B86** **P.S. Druckenmiller**, **K. Johnson**, **J. Ramezani**, **K. Tsukui**, **P. McCarthy**, **Z.R. Perry**, **P. Flaig**, **D. van der Kolk**, **C. Brown**, **G.M. Erickson** FIRST U-PB CA-ID-TIMS AGE CONSTRAINTS ON POLAR DINOSAURS FROM THE PRINCE CREEK FORMATION, NORTHERN ALASKA

**B87** **I.M. Matteson**, **D.J. Varricchio**, **K. Matteson** THE HUMPTY DUMPTY PROTOCOL: PREDICTING THE INITIAL VOLUME OF EGGS FROM CRUSHED REMAINS

**B88** **V. Arbour**, **D. Ball**, **P. Rombough**, **D.W. Larson**, **C. Scott**, **L.T. Dickson**, **E. Cross** DINOSAUR FOOTPRINTS FROM THE UPPER CRETACEOUS NANAIMO GROUP OF VANCOUVER ISLAND, BRITISH COLUMBIA, CANADA

**B89** **G.B. Lafaye**, **D.J. Varricchio** EXPANDING THE KNOWN VERTEBRATE RECORD OF THE MID CRETACEOUS BLACKLEAF FORMATION AND THE IMPLICATIONS FOR THE MID CRETACEOUS OF WESTERN NORTH AMERICA AS A WHOLE

**B90** **W. McCuen**, **L.E. Zanno** REASSESSMENT OF VERTEBRATE MICROFOSSILS FROM THE STRAIGHT CLIFFS FORMATION (TURONIAN-CAMPANIAN) OF SOUTHERN UTAH

**B91** **J.E. Peterson**, **J.M. McCloskey**, **J.P. Warnock**, **C.D. Dooms** VERTEBRATE ICHNOFOSSILS FROM JURASSIC NATIONAL MONUMENT, UPPER MORRISON FORMATION, UTAH - A PRELIMINARY CENSUS

**B92** **C.J. McClellan**, **B. Britt**, **R. Scheetz** THE IMPACT OF INSECTS ON DINOSAUR BONES FROM THE GRAY ASH QUARRY (YELLOW CAT MEMBER OF THE CEDAR MOUNTAIN FORMATION, EARLY CRETACEOUS, BAREMMIAN), NEAR ARCHES NATIONAL PARK, UTAH, USA

**B93** **W. Beatty**, **A.J. Schroeder**, **C.L. Kairies-Beatty** *TYRANNOSAURUS* BITE MARKS ON A CERATOPSID FRILL FROM THE LATE CRETACEOUS HELL CREEK FORMATION OF NORTH DAKOTA, USA

**B94** **W. Reyes**, **M. Brown** THE SKELETAL MORPHOLOGY OF A HYPOTHETICALLY JUVENILE AETOSAUR SPECIMEN FROM THE LATE TRIASSIC DOCKUM GROUP (OTISCHALKIAN) OF TEXAS

**B95** **C.N. LePore**, **M.A. McLain** DID PHYTOSAURS SWEEP LIKE GHARIALS OR SHAKE LIKE GATORS?: A PRELIMINARY COMPARISON OF PHYTOSAUR AND CROCODYLIAN VERTEBRAL COLUMNS WITH IMPLICATIONS FOR PHYTOSAUR FEEDING MODES

**B96** **A.W. Kellner** COMMENTS ON PTEROSAUR BONE BEDS

**B97** **M.F. Guenther**, **I. Dilollo** REEXAMINING DIVERSIFICATION DYNAMICS OF THE PTEROSAURIA

**THURSDAY MORNING, OCTOBER 19, 2023**
**ROMER PRIZE SESSION**
**MEETING ROOM JUNIOR BALLROOM A/B**
**MODERATORS: Susannah Maidment and Advait Jukar**

**8:00** **A.E. Kort** FUNCTIONAL DIVERSIFICATION OF LUMBAR VERTEBRAE IN PALEOGENE MAMMALS

**8:15** **T. Lowi-Merri** THE EVOLUTION OF STERNUM-DRIVEN POWERED FLIGHT IN PENNARAPTORA

**8:30** **C.H. Woolley** NOVEL APPROACHES TO EVALUATING THE QUALITY OF THE GLOBAL FOSSIL RECORD: THE FRONTIER BETWEEN TAPHONOMY AND PHYLOGENETICS

**8:45** **E. Steell** UNTANGLING COMPLEX MORPHOLOGICAL EVOLUTION IN THE HYPERDIVERSE PASSERINE BIRD RADIATION

**9:00** **Z. Qin**, **S. Wang**, **W. Deakin**, **Y. Liu**, **C. Yu**, **X. Xu**, **M. Benton**, **E. Rayfield** MORPHOLOGICAL DIVERSITY AND FUNCTIONAL ADAPTATIONS OF MANIRAPTORAN MANUAL CLAWS

**9:15** **D.J. Morgan** HANDLING THE PRESSURE: CONVERGENCE IN VASCULAR ADAPTATIONS FOR MITIGATING HYDROSTATIC PRESSURES ASSOCIATED WITH DIVING IN MOSASAURS AND PLESIOSAURS

**9:30** **Z.T. Kulik** HISTOLOGICAL INSIGHTS INTO THE EVOLUTION OF MAMMALIAN GROWTH TRAJECTORIES FROM COMPARATIVE HISTOLOGY OF NON-MAMMALIAFORM CYNODONTS

**9:45** **A. Howard** DIGGING DEEPER INTO SNAKE ORIGINS: BODY SIZE EVOLUTION AND ECOMORPHOLOGICAL CORRELATES TO FOSSORIALITY PROVIDE NEW DATA ON THE ECOLOGICAL ORIGINS OF SNAKES

**10:15** **R.S. Smyth** NEW, INTEGRATED MORPHOMETRIC AND ICHNOLOGICAL DATASETS RESHAPE OUR UNDERSTANDING OF PTEROSAUR TERRESTRIAL ECOLOGY

**10:30** **B. Otoo** BENEATH THE SURFACE: COMMUNITY STRUCTURE PERSISTS THROUGH END-DEVONIAN MASS EXTINCTION DESPITE MORPHOLOGICAL DISPARITY AMONG EARLY TETRAPODS AND MULTIPLE TERRESTRIALIZATIONS WITHIN THE CROWN GROUP

**10:45** **A. DeMers** GETTING BACK TO OUR ROOTS: WHAT TOOTH ROOT NUMBER CAN TELL US ABOUT THE ECOLOGY AND PHYLOGENY OF FOSSIL MAMMALS

**11:00 K.K. Formoso** CORRELATIONS BETWEEN DEGREE OF AXIAL AND APPENDICULAR CHANGE, DERIVED SWIMMING STYLE, AND ANCESTRAL TERRESTRIAL STATE IN SECONDARILY AQUATIC AMNIOTES

**11:15 J.D. Hogan** EXPERIMENTAL EXAMINATION OF PENNARAPTORAN NESTING HABITS AND THE TRANSITION FROM CROCODILIAN-LIKE NEST GUARDING TO AVIAN CONTACT INCUBATION

**11:30 S. Pommerening** JAW MECHANICS IN SHREWS AND THE ROLE OF THE DOUBLE ARTICULATION

**11:45 A.J. Rowe** SKULL FUNCTION IN THEROPOD DINOSAURS: IMPLICATIONS FOR BODY SIZE AND MACROEVOLUTION

**12:00 J.S. Keller** CLIMATE AND BIODIVERSITY LOSS SHAPE MICROMAMMAL COMMUNITY ECOLOGY OVER THE LAST 22,000 YEARS AT HALL'S CAVE, TEXAS

**THURSDAY MORNING, OCTOBER 19, 2023**
**TECHNICAL SESSION 7: BIRDS**
**MEETING ROOM JUNIOR BALLROOM C**
**MODERATORS: Lauren Wilson and Meig Dickson**

**8:00 A. Clark**, **J. O'Connor**, **W. Xiaoli**, **X. Zhang**, **X. Wang**, **X. Zheng**, **Z. Zhou** FIRST EDENTULOUS ENANTIORNITHINE FROM THE JEHOL AVIFAUNA BIOTA

**8:15 D.J. Field**, **J. Benito**, **A. Chen**, **P. Kuo**, **K.E. Widrig**, **D.T. Ksepka**, **J. Jagt** TWO SPECIAL LUMPS OF STONE: INSIGHTS INTO MODERN BIRD ORIGINS FROM THE TYPE MAASTRICHTIAN

**8:30 J. Benito**, **E. Steell**, **K.E. Widrig**, **D.J. Field** NEW DATA ON LATE CRETACEOUS STEM BIRDS CLARIFIES THE PLESIOMORPHIC CONDITION OF THE NEORNITHINE POSTCRANIAL SKELETON

**8:45 P. Kuo**, **G. Navalón**, **R. Benson**, **D.J. Field** ECOMORPHOLOGY AND MACROEVOLUTION OF THE AVIAN QUADRATE

**9:00 A. Chen**, **E. Steell**, **R. Benson**, **D.J. Field** RAMPANT HOMOPLASY IN THE PECTORAL GIRDLE AND FORELIMB SKELETON OF CROWN BIRDS: IMPLICATIONS FOR MORPHOLOGICAL PHYLOGENETICS AND SYSTEMATIC PLACEMENT OF AVIAN FOSSILS

**9:15 M.C. Dickson** NEORNITHINE RANGE RESPONSE TO PALEOGENE GLOBAL WARMING

**9:30 E. Alger-Meyer**, **T.A. Gates** QUANTIFYING THE CONVERGENCE OF AVIAN CRANIAL OUTGROWTHS: A PRELIMINARY STUDY OF INTERACTIONS BETWEEN NATURAL AND SEXUAL SELECTION

**9:45 J. OConnor**, **A. Clark**, **F. Herrera**, **Z. Zhou**, **W. Xiaoli**, **X. Zheng** *LONGIPTERYX* STOMACH CONTENTS INDICATE THAT MORPHOLOGY DOES NOT ACCURATELY PREDICT DIET IN ENANTIORNITHINES

**10:15 L.N. Wilson**, **D. Ksepka**, **J. Wilson**, **C. Brown**, **J.J. Eberle**, **D. Brinkman**, **G.M. Erickson**, **P.S. Druckenmiller** AVIALAN NESTING IN THE ARCTIC TRACES BACK TO THE CRETACEOUS

**10:30 H.R. Caldwell**, **E. Bedolla**, **D.J. Varricchio** PATTERNS OF POSTCRANIAL SUTURE CLOSURE IN THE EMU (*DROMAIUS NOVAEHOLLANDIAE*) WITH IMPLICATIONS FOR THE INTERPRETATION OF ONTOGENETIC STAGES IN ARCHOSAURS

**10:45 C. Griffin**, **Z.S. Morris**, **B.S. Bhullar** THE DEVELOPMENTAL MECHANISMS UNDERLYING THE EVOLUTION OF THE AVIAN PELVIS FROM THE ANCESTRAL ARCHOSAURIAN CONDITION

**11:00 G. Navalon**, **L.M. Chiappe**, **R. Benson**, **A. Martinelli**, **W. Nava**, **D.J. Field** WELL-PRESERVED ENANTIORNITHINE CRANIAL REMAINS ILLUMINATE COMPLEX ORIGINS OF THE MODERN BIRD CENTRAL NERVOUS SYSTEM

**11:15 C. Holliday**, **A. Wilken**, **K. Sellers**, **L.M. Witmer**, **K. Middleton** AVIAN CRANIAL KINESIS IS THE RESULT OF INCREASED ENCEPHALIZATION DURING THE ORIGIN OF BIRDS

**11:30 K.E. Widrig**, **H.F. James**, **D.J. Field** QUANTITATIVE ANALYSIS OF FLIGHT CAPACITY IN A PALEOCENE STEM PALAEOGNATH

**11:45 C. Kingwill** TIMING OF DIVERSIFICATION, DISPERSAL, AND BIOGEOGRAPHY OF PARROTS IN THE GENUS *AMAZONA* (PSITTACIFORMES: PSITTACIDAE) THROUGHOUT THE CARIBBEAN, VISUALIZED IN GIS

**12:00 T.S. Slater**, **N.P. Edwards**, **S.M. Webb**, **F. Zhang**, **M.E. McNamara** TWO BIRDS WITH ONE STONE: THE TAPHONOMY OF FEATHER PROTEINS AND THE BIOCHEMICAL EVOLUTION OF FEATHERS

**THURSDAY MORNING, OCTOBER 19, 2023**
**PREPARATORS' SESSION**
**MEETING ROOM JUNIOR BALLROOM D**
**MODERATORS: Matthew Miller and Vanessa Rhue**

**8:00** **F. Duffy**, **H. Petermann**, **E. Lessner**, **L.G. Dougan**, **T. Lyson**, **K. Chin** FOSSILS IN FOCUS: ASSESSING THE POTENTIAL OF ACCELERATING DIGITAL PREPARATION WITH AI-ASSISTED SEGMENTATION ACROSS MULTIPLE FOSSIL TYPES

**8:15** **A.E. Gordon** ASSESSMENT OF JACKET TENSILE & FLEXURAL STRENGTH FOR SOME COMMON PLASTER JACKETING FABRICS

**8:30** **M. Fox**, **C. Lutz**, **C. Lash** NO SAW SUPPORT JACKETS

**8:45** **A. Shinya**, **K. Wada**, **T. Tanaka**, **T. Ikeda** THE CHALLENGE OF HARD-TO-REACH SPACES IN MECHANICAL FOSSIL PREPARATION: DEVELOPMENT OF A NOVEL SHORT-BODIED AIR SCRIBE WITH A FLEXIBLE HEAD

**9:00** **L.G. Dougan**, **E. Lessner**, **H. Petermann**, **T. Lyson**, **E. Panigot**, **F. Duffy** BONES TO BYTES: COMPUTED TOMOGRAPHY DATA PREPARATION AND VISUALIZATION STRATEGIES FOR LARGE, COMPLEX FOSSIL DATASETS

**9:15** **S. Morley**, **S. Potze** LIMPING ALONG: CONSERVATION OF A PATHOLOGICAL *SMILODON FATALIS* PELVIS AND FEMUR FOR EXHIBITION FROM RANCHO LA BREA, CALIFORNIA

**9:30** **H.M. Avrahami**, **L. Herzog** ADVANCES IN 3D SURFACE SCANNING: MOBILE DEVICE APPLICATIONS SET A NEW STANDARD FOR THE DIGITIZATION OF FOSSILS AND MUSEUM ARTIFACTS

**9:45** **L. Herzog**, **J. Anné**, **E.K. Lund**, **A. Knowles**, **H.M. Avrahami**, **L.E. Zanno** NO TOUCH TRANSFER OF SKIN IMPRESSION TO RESIN PRINT: APPLICATION OF THE LINDOE TECHNIQUE

**10:15** **L. Hall**, **S.A. Williams**, **L. Meld**, **C. Knight**, **J. Scannella**, **E.T. Metz**, **E. Lamm**, **C. Dobbs** NEVER GIVE UP, NEVER SURRENDER: PLANNING AND CONSTRUCTING DUST EXTRACTION SYSTEMS IN TWO FOSSIL PREPARATION FACILITIES AT MUSEUM OF THE ROCKIES

**10:30** **J.A. Moretti** CHALLENGES AND SOLUTIONS FOR RECOVERING QUATERNARY SMALL FELINE FOSSILS FROM THE DUNGEON, A PIT ROOM DEEP WITHIN NATURAL BRIDGE CAVERNS, COMAL COUNTY, TEXAS.

**10:45** **E. Lund**, **L. Herzog**, **J. Anné**, **A. Knowles**, **L.E. Zanno** WORKING WITH GIANTS: LOGISTICS AND SAFETY OF MOVING, ROTATING, AND PREPARING OVERSIZED, MULTI-TON FOSSIL BLOCKS

**11:00** **J. Groenke**, **P.M. O'Connor** ENHANCED RESOLUTION AT THE MECHANICAL-DIGITAL INTERFACE: A METHODOLOGY TO ASSIST IN PREPARATION DECISION MAKING AND IMPROVED RESEARCH AND OUTREACH OUTCOMES

**11:15** **T. Keillor**, **P.C. Sereno** DESIGN AND SAFE JOURNEY TO A 21ST-CENTURY FOSSIL LAB

**11:30** **M. Householder**, **C.A. Boyd** THE IMPACT OF ADHESIVES, CONSOLIDANTS, AND SOLVENTS ON GEOCHEMICAL DATA: AN EXAMPLE USING X-RAY FLUORESCENCE

**11:45** **J. Anné**, **E.K. Lund**, **A. Knowles**, **L. Herzog**, **L.E. Zanno** STABILIZING WITHOUT COMPROMISING: USING CASTING SAND TO STABILIZE FOSSIL BLOCKS

**12:00** **R. Dunn**, **A.L. Wurtz**, **A.B. Heckert** HYDROGEN PEROXIDE BREAKDOWN OF FOSSILIFEROUS SEDIMENTS FROM UPPER CRETACEOUS MICROVERTEBRATE SITES IN THE WILLIAMS FORK FORMATION, NORTHWESTERN COLORADO

**THURSDAY AFTERNOON, OCTOBER 19, 2023**
**SYMPOSIUM: THEROPOD FLIGHT ORIGINS**
**MEETING ROOM JUNIOR BALLROOM A/B**
**MODERATORS: Michael Pittman and Hila Tzipora Chase**

**1:45** **H. Chase** BIRDS, BONES, AND BASIC BIOLOGY: IDENTIFYING ISSUES OF INTEGRATION

**2:00** **M.B. Habib** EVOLUTION OF THE UPSTROKE IN THEROPOD FLIGHT

**2:15** **M. Pittman**, **N.S. Haidr**, **S. Catalano** HETEROCHRONIC CHANGES AS MEANS OF WING EVOLUTION IN PENNARAPTORANS?

**2:30** **S.L. Baumgart**, **P.C. Sereno** MORPHOLOGY AND PNEUMATICS OF A PTEROSAUR WING (PTEROSAURIA: ORNITHOCHEIROMORPHA) FROM THE ELRHAZ FORMATION (APTIAN-ALBIAN) OF NIGER

**2:45** **M.F. Jones**, **J.R. Baez**, **N.S. Upham**, **K. Beard**, **N.B. Simmons** EVOLUTION OF EOCENE BATS AND THE ORIGINS OF MODERN GROUPS

**3:00** **M. Grosmougin**, **T.G. Kaye**, **M. Chotard**, **L.A. Barlow**, **X. Wang**, **X. Zheng**, **M. Pittman** NEW INFORMATION ON THE SOFT TISSUES AND BONE ANATOMY OF THE FOREWINGS CONSTRAINS THE POWERED FLIGHT PERFORMANCE OF *MICRORAPTOR* (THEROPODA: DROMAEOSAURIDAE)

**3:15** **M. Chotard**, **T.G. Kaye**, **M. Grosmougin**, **L.A. Barlow**, **W. Xiaoli**, **X. Zheng**, **M. Pittman** NEW INFORMATION ON THE STRUCTURE OF THE HINDWING SHEDS LIGHT ON FLIGHT PERFORMANCE OF *MICRORAPTOR* (THEROPODA: DROMAEOSAURIDAE)

**3:30** **C. Hefler**, **W. Ying**, **M. Grosmougin**, **M. Chotard**, **M. Pittman** UNSTEADY AERODYNAMIC FEATURES AND WING-WING INTERACTIONS IN MICRORAPTOR FLIGHT

**3:45** **M. Pittman**, **T.A. Dececchi**, **K. Kim**, **M.G. Lockley**, **H.C. Larsson**, **T.H. Holtz Jr.**, **J.O. Farlow** THEROPOD TRACKWAY FROM THE CRETACEOUS OF SOUTH KOREA PROVIDES EVIDENCE OF AERIAL BEHAVIOR IN NON-AVIALAN PARAVIANS

**4:00** **T.A. Dececchi**, **I. (23 authors)**, **M. Pittman** FUTURE DIRECTIONS IN THE STUDY OF THEROPOD FLIGHT ORIGINS

**THURSDAY AFTERNOON, OCTOBER 19, 2023**
**TECHNICAL SESSION 8: MAMMAL PALEOECOLOGY**
**MEETING ROOM JUNIOR BALLROOM C**
**MODERATORS: Alex Shupinski and Tara Smiley**

**1:45** **T.M. Smiley**, **E. Marder**, **B. Yanites** COUPLED LANDSCAPE AND BIOTIC EVOLUTION MODEL REVEALS DEEP-TIME HISTORY OF THE TOPOGRAPHIC DIVERSITY GRADIENT

**2:00** **D. Reuter**, **J. Wainwright**, **S. Hopkins**, **S. Blumenthal** OREGON OLIGO-MIOCENE HERBIVORE COMMUNITY NICHE PARTITIONING: SYNTHESIS AND INSIGHTS FROM STABLE ISOTOPE ANALYSIS

**2:15** **C. Ward**, **B.E. Crowley**, **R. Secord** HOME ON THE RANGE: A MULTI-ISOTOPE INVESTIGATION OF UNGULATE RESOURCE PARTITIONING FROM ASHFALL FOSSIL BEDS, NEBRASKA, USA

**2:30** **D.L. Fox**, **W. Lukens** REASSESSING THE NEOGENE HISTORY OF $C_4$ GRASSES IN THE GREAT PLAINS, U.S.A.

**2:45** **W. Lukens**, **D.L. Fox**, **A.L. Deino**, **R. Kinyanjui**, **L. Michel**, **A. Novello**, **D.J. Peppe**, **C.A. Strömberg**, **K. Uno**, **J.D. Kingston** EARLY MIOCENE EVIDENCE FOR ABUNDANT $C_4$ VEGETATION AND HABITAT HETEROGENEITY IN EASTERN AFRICA

**3:00** **J. Pirlo** NICHE PARTITIONING AMONG THE HERBIVORES OF NORTH-CENTRAL FLORIDA IN THE LATE MIOCENE-EARLY PLIOCENE

**3:15** **A. Shupinski**, **F.A. Smith**, **K. Lyons** CHANGES IN CO-OCCURRENCE STRUCTURE OF NORTH AMERICAN MAMMAL PALEOCOMMUNITIES ACROSS THE PLIO-PLEISTOCENE TRANSITION

**3:30** **L. DeSantis**, **G.J. Price**, **J. Louys** THE PLIO-PLEISTOCENE IS A CLEAR DEPARTURE FROM THE PRESENT: ECOLOGICAL SHIFTS EVIDENCED FROM FAUNA AT THE DARLING DOWNS, QUEENSLAND, AUSTRALIA

**3:45** **F.A. Smith**, **E.A. Elliott Smith**, **A. Villasenor**, **C. Tomé**, **K. Lyons**, **S. Newsome** THE INFLUENCE OF THE TERMINAL PLEISTOCENE EXTINCTION ON ECOLOGICAL COMPLEXITY AND PREDATOR PREY INTERACTIONS WITHIN A MAMMAL COMMUNITY

**4:00** **WITHDRAWN**

**THURSDAY AFTERNOON, OCTOBER 19, 2023**
**TECHNICAL SESSION 9: SAUROPSIDS**
**MEETING ROOM JUNIOR BALLROOM D**
**MODERATORS: Xavier Jenkins and Kayla Bazzana-Adams**

**1:45** **K. Bazzana-Adams**, **D. Evans** LONGER COCHLEAE DO NOT RELATE TO HIGHER FREQUENCY HEARING IN SAUROPSIDS

**2:00** **R. Butler**, **L. Meade**, **T. Cleary**, **K. McWhirter**, **E. Brown**, **N. Fraser**, **T. Kemp**, **J. Benito** A NEW PROCOLOPHONID FROM THE LATE TRIASSIC FISSURE FILL AT CROMHALL QUARRY, SOUTHWEST ENGLAND

**2:15** **WITHDRAWN**

**2:30** **M.J. Van den Brandt**, **J. Cisneros**, **F. Abdala**, **E. Boyarinova**, **V.K. Golubev**, **L.A. Norton**, **R.M. Smith**, **B.S. Rubidge** A RE-DESCRIPTION OF THE LATE PERMIAN PAREIASAUR *NANOPARIA LUCKHOFFI* (BROOM 1936) FROM THE KAROO BASIN OF SOUTH AFRICA, AND A NEW CONSOLIDATED PAREIASAURIAN PHYLOGENY

**2:45** **W.I. Pugh**, **M. Sodano**, **B.T. Kligman**, **M.R. Stocker**, **S.J. Nesbitt** CLAWS IN THE CAUDALS; UNIQUE MORPHOLOGY AMONG DREPANOSAURID (DIAPSIDA) CAUDAL ELEMENTS

**3:00** **A. Huttenlocker**, **J. Pardo**, **R. Irmis**, **S.S. Sumida** DENTAL COMPLEXITY AND CONVERGENCE IN CARBONIFEROUS-PERMIAN REPTILES: NEW μCT EVIDENCE FROM *PUERCOSAURUS OBTUSIDENS*

**3:15** **WITHDRAWN**

**3:30** **X.A. Jenkins**, **R.B. Benson**, **J. Choiniere**, **D. Ford**, **B.R. Peecook** POSTCRANIAL PLESIOMORPHIES AND HINDERING HOMOPLASY: THE IMPORTANCE OF TAXONOMIC AND POSTCRANIAL CHARACTER SAMPLING IN EARLY AMNIOTE PHYLOGENIES

**3:45** **L.E. Roberts**, **J. Head** DIVERGENT EVOLUTIONARY HISTORIES IN THE EVOLUTION OF AXIAL SKELETAL COMPLEXITY BETWEEN REPTILES AND MAMMALS

**4:00** **S.A. Martinez**, **K.M. Melstrom**, **K.D. Angielczyk** CONSIDERING ALL TOOTH-BEARING BONES DEMONSTRATES ELEVATED TOOTH COMPLEXITY AMONG EARLY TETRAPOD HERBIVORES

**THURSDAY AFTERNOON, OCTOBER 19, 2023**
**PREPARATORS' POSTER SESSION**
**MEETING ROOM GRAND BALLROOM B**
**Authors must be present from 4:30 – 6:30 p.m. on Thursday, October 19**

**B98** **T. Sato** MOLDMAKING AROUND ARMATURES ON A TILTED PEDESTAL: A CASE STUDY OF LARGE-SCALE FOSSIL WHALE MANDIBLES AND BALEEN IMPRESSIONS

**B99** **M. Brown** QUANTIFYING THE IMPACT OF FOSSIL PREPARATORS THROUGH TIME

**B100** **M. Slovacek** 'NATURE-FAKED' LAY-UP URETHANE PLASTIC METHODOLOGY FOR SAFER HOLLOW-CAST MAKING

**B101** **A.C. Henrici** AN IMPROVED SYSTEM FOR STORAGE OF MICROFOSSILS AT CARNEGIE MUSEUM OF NATURAL HISTORY

**B102** **C. Lash**, **C. Lutz** INNOVATIVE TECHNIQU **-WITHDRAWN-** STRUCTION: A CASE STUDY OF TWO SKULLS

**B103** **B. Szafron**, **A. Davidson** PROBLEM-SOLVING FOR PREPARING VERY THIN BONE - A SMALL THEROPOD ILIUM CASE STUDY

**B104** **E. Panigot**, **E. Burns**, **H. Petermann**, **T. Lyson**, **B.S. Rubidge**, **G.S. Bever** AUGMENTING ANATOMICAL RECONSTRUCTION OF VERTEBRATE FOSSIL CRANIA - A CASE STUDY OF 3D PRINTING FOR RESEARCH, OUTREACH, AND EXHIBITS

**B105** **V.L. Dill**, **B. Zimmer**, **S. Marshall**, **C. Liutkus-Pierce** DETECTING EROSION AT THE ENGARE SERO HOMINID FOOTPRINT SITE, TANZANIA, AND IMPLICATIONS FOR *IN SITU* TRACKWAY CONSERVATION

**THURSDAY AFTERNOON, OCTOBER 19, 2023**
**REGULAR POSTER SESSION 2**
**MEETING ROOM GRAND BALLROOM B**
**Authors must be present from 4:30 – 6:30 p.m. on Thursday, October 19**

**B106** **N. Baird**, **B. Slibeck** FAST, CHEAP, OR GOOD – PICK TWO: TRADE-OFFS IN 3D MODELING TECHNIQUES FOR PALEONTOLOGICAL SPECIMENS

**B107** **Z.J. Lyons-Weiler** REANALYSIS OF A PENNSYLVANIAN VERTEBRATE ASSEMBLAGE FROM THE EASTERN UNITED STATES PROVIDES INSIGHTS INTO DIVERSITY AND PALEOBIOGEOGRAPHY

**B108** **S. El-Sayed**, **M. Friedman**, **P.M. O'Connor**, **J.J. Sertich**, **E. Sieffert**, **B.S. Salem**, **H.M. Sallam** ACTINOPTERYGIAN FISH ASSEMBLAGE FROM THE UPPER CRETACEOUS (CAMPANIAN-MAASTRICHTIAN) DUWI FORMATION, WESTERN DESERT, EGYPT

**B109** **C. Fielitz**, **Z. DeWees**, **H. Jackson** A NON-OTOLITH, ACANTHOMORPH FISH SPECIMEN FROM THE COON CREEK FORMATION (LATE CRETACEOUS: MAASTRICHTIAN) OF MISSISSIPPI, USA

**B110** **E.J. Hilton**, **L. DeHaan**, **S. El-Sayed**, **M. Montalvo**, **H. Saad**, **M. Friedman** TELEOSTEAN FISHES FROM THE MIDDLE EOCENE HABIB RAHI AND DOMANDA FORMATIONS OF PAKISTAN

**B111** **K.E. Mickle**, **M.D. Gottfried** LOWER ACTINOPTERYGIAN FISHES FROM THE UPPER PENNSYLVANIAN HAMILTON QUARRY, A KONSERVAT-LAGERSTÄTTE IN SOUTHEASTERN KANSAS, U.S.A.

**B112** **M.V. Carbi**, **K.E. Bemis**, **M. Friedman**, **W.E. Bemis** ELONGATED PELVIC BONE IN AN EOCENE THREE-TOOTH PUFFER (TETRAODONTIFORMES: TETRAODONTIDAE) SUGGESTS PRESENCE OF PELVIC FAN

**B113** **M.A. During**, **S. Goderis**, **R. Gess**, **P. Claeys**, **P. Ahlberg** UNIQUE PRESERVATION AND REE ENRICHMENT OF FAMENNIAN FOSSILS FROM THE WATERLOO FARM DEPOSIT, SOUTH AFRICA

**B114** **M.A. Skowronski**, **K. Shimada** A NEW SKELETAL SPECIMEN OF AN ENIGMATIC PLETHODID BONY FISH (ACTINOPTERYGII: TSELFATIIFORMES) FROM THE UPPER CRETACEOUS EAGLE FORD SHALE, TEXAS, USA

**B115** **S.N. van Mesdag**, **K. Trinajstic**, **Z. Johanson** THE PELVIC GIRDLE IN *MILLEROSTEUS MINOR* AND OTHER DEVONIAN ARTHRODIRAN PLACODERMS

**B116** **S. Yao**, **G. Young**, **Y. Zhu**, **J. Lu** NEUROCRANIAL ANALYSIS OF AN EARLY DEVONIAN ARTHRODIRE PLACODERM SHEDS LIGHT ON EARLY GNATHOSTOME BRAIN EVOLUTION

**B117** **S.M. Palmer**, **J.P. Rule**, **S.B. Cooke** COMPARATIVE MANDIBULAR MORPHOLOGY OF EXTINCT AND EXTANT CROWN PINNIPEDS

**B118** **B. Figueirido**, **J. Esteban**, **A. Martin-Serra**, **A. Perez Ramos**, **J.A. Pérez-Claros** THE EVOLUTION OF THE PINNIPED (MAMMALIA, CARNIVORA, PINNIPEDIA) BACKBONE

**B119** **C.J. Everett** A COMPREHENSIVE PHYLOGENY OF PINNIPEDIMORPHA REVEALS AN ALTERNATIVE HYPOTHESIS OF CROWN PINNIPED RELATONSHIPS

**B120** **E. Medeiros**, **M.D. Nelson**, **M.D. Uhen** PATTERNS OF LATITUDINAL DISTRIBUTION OF CETACEA AS OBSERVED BETWEEN ANCIENT AND MODERN TAXA

**B121** **A. Kaur**, **M. Sisk** A MAXENT PREDICTIVE MODEL FOR PALEONTOLOGICAL SITES IN THE SIWALIK HILLS; A CASE STUDY FROM THE PINJORE FORMATION OF THE SIWALIK HILLS NORTH OF CHANDIGARH, NORTHERN INDIA

**B122** **G. DeVault**, **A.K. Hastings**, **C. Iverson** REPTILES AND MAMMALS AND FISH, OH MY: DIGITIZATION OF THE SCIENCE MUSEUM OF MINNESOTA'S PALEOCENE WANNAGAN CREEK COLLECTION FROM NORTH DAKOTA

**B123** **B.T. Kligman**, **P.E. Olsen**, **J. Villari**, **K. Hughes**, **J. Montenegro**, **A.C. Pritchard**, **T. Reichgelt**, **L. Park Boush** A NEW LACUSTRINE MARGIN VERTEBRATE ASSEMBLAGE FROM THE EARLY JURASSIC WATERFALL FORMATION OF VIRGINIA, U.S.A.

**B124** **A. Chaudhary**, **B.L. Beatty**, **A. Moore** HOW ROUGH? ASSESSING THE UTILITY OF BONE SURFACE MICROTEXTURE AS A CORRELATE FOR PNEUMATIC DIVERTICULA.

**B125** **D.E. Barta** ONTOGENETIC STATUS OF A PHYTOSAUR (REPTILIA: ARCHOSAURIFORMES) SPECIMEN FROM THE UPPER TRIASSIC SLOAN CANYON FORMATION OF THE DRY CIMARRON VALLEY, OKLAHOMA, U.S.A, AS REVEALED BY FIBULAR OSTEOHISTOLOGY

**B126** **S.H. Burch**, **C. Dupont**, **A.C. Green**, **J.R. Hutchinson** EVOLUTION OF THE ARCHOSAURIAN SHOULDER MUSCULATURE

**B127** **M.R. Stocker**, **D. Foffa**, **S.J. Nesbitt**, **G. Iannacone**, **V. Yarborough** AN ARTICULATED PHYTOSAUR TAIL FROM TEXAS AND SUPPORT FOR ECOLOGICAL DIFFERENTIATION WITHIN THE CLADE

**B128** **D.B. Patterson**, **A. Tomcho**, **M. Dickens**, **A. Mead**, **H. Mead**, **G. Bennett**, **C. Seminack**, **F. Robb** LATE PLEISTOCENE ECOSYSTEM EVOLUTION IN SOUTHEASTERN NORTH AMERICA: A TRANSDISCIPLINARY APPROACH USING MODERN AND FOSSIL AMERICAN ALLIGATOR (*ALLIGATOR MISSISSIPPIENSIS*) ENAMEL ISOTOPES

**B129** **B. Rakotozafy**, **J.J. Sertich**, **P.M. O'Connor** CRANIAL ONTOGENY IN THE NOTOSUCHIAN CROCODYLIFORM *MIADANASUCHUS OBLITA* FROM THE UPPER CRETACEOUS MAEVARANO FORMATION, NORTHWESTRN, MADAGASCAR

**B130** **A. Collett**, **H.P. Tsai** ONTOGENY-INDUCED SHAPE CHANGES IN THE PROXIMAL FEMUR OF THE AMERICAN ALLIGATOR (*ALLIGATOR MISSISSIPPIENSIS*)

**B131** **J.T. Deckhut**, **Z. Boles** AN EXCEPTIONALLY YOUNG JUVENILE CF. *BOTTOSAURUS HARLANI* SPECIMEN FROM THE MAIN FOSSILIFEROUS LAYER OF THE CRETACEOUS-PALEOGENE HORNERSTOWN FORMATION AT THE EDELMAN FOSSIL PARK IN MANTUA TOWNSHIP, NEW JERSEY

**B132** **K. Lindblad**, **E. Bamforth** SASKATCHEWAN EUSUCHIAN CENSUS: NEW CRETACEOUS AND PALEOGENE CROCODYLIFORM SPECIMENS FROM THE CANADIAN PRAIRIES

**B133** **N.C. Platt**, **A.A. Brink**, **C.A. Brochu** GONIOPHOLIDID DIVERSITY IN CRETACEOUS NORTH AMERICA: INSIGHTS FROM NEW SPECIES

**B134** **J. Schaeffer**, **E. Mujal**, **F. Witzmann**, **G. Ferreira**, **R.R. Schoch** PATHOLOGICAL CHEVRONS IN THE TAILS OF THREE SPECIMENS OF *PLATEOSAURUS TROSSINGENSIS*

**B135** **E. Gorscak**, **M. Lamanna**, **B.S. Salem**, **S. El-Sayed**, **H.M. Sallam** RE-EVALUATION OF THE GIGANTIC TITANOSAURIAN SAUROPOD DINOSAUR *PARALITITAN STROMERI* FROM THE MID-CRETACEOUS BAHARIYA FORMATION OF EGYPT AND ITS PHYLOGENETIC RELATIONSHIPS TO OTHER EXCEPTIONALLY LARGE TITANOSAURS

**B136** **K. Curry Rogers**, **V. Díez Díaz**, **R. Rogers**, **D.W. Krause** MORPHOLOGICAL DISPARITY IN THE CAUDAL VERTEBRAL SEQUENCE OF *RAPETOSAURUS KRAUSEI* (SAUROPODA: TITANOSAURIA), FROM THE UPPER CRETACEOUS MAEVARANO FORMATION OF MADAGASCAR

**B137** **M.R. Acosta**, **E. Koenig**, **O.H. Blomberg**, **A.M. Kufner**, **Y. Haridy**, **D.M. Lovelace** A UNIQUE PATHOLOGY IN AN APATOSAURINE (SAUROPODA, DIPLODOCIDAE) FEMUR FROM THE MORRISON FORMATION (UPPER JURASSIC) OF WYOMING, USA

**B138** **T. Gallagher**, **D. Folkes**, **J. Schein**, **G.W. Storrs**, **J. Vinther** DIPPY LONGSTOCKINGS: PRESENCE OF MELANOSOME IMPRESSIONS IN *DIPLODOCUS* SP. SCALES EXPANDS OUR KNOWLEDGE OF SAUROPOD COLORATION

**B139** **G.A. Goetcheus** A PALEOPATHOLOGIC SURVEY OF A *DIPLODOCUS SP.* (SAUROPODA: DIPLODOCIDAE) POPULATION FROM THE MORRISON FORMATION (KIMMERIDGIAN) OF MONTANA, USA

**B140** **J. McHugh** AN UNUSUAL MIXTURE OF ONTOGENETIC STAGES OF DIPLODOCID SAUROPODS IN THE MYGATT-MOORE QUARRY ASSEMBLAGE (MORRISON FORMATION)

**B141** **J.E. Diepenbrock**, **M.T. Clementz** PARDON MY PLASTER: REANALYSIS OF THE HISTORICALLY IMPORTANT APATOSAURINE SPECIMEN UW15556

**B142** **T. Xu**, **M. Kemp** DOES SCALE MATTER? CONSERVED EVOLUTIONARY ALLOMETRIES ACROSS DIVERSE *ANOLIS* LIZARD ECOMORPHS

**B143** **R.S. Tykoski**, **M.J. Polcyn** "'TIS BUT A SCRATCH!" SAID THE BLACK KNIGHT; SEVERE FACIAL PATHOLOGIES IN A *TYLOSAURUS* FROM THE OZAN FORMATION (CAMPANIAN) OF NORTHEAST TEXAS

**B144** **D.G. DeMar**, **G. Bennett** A NEW PLATYNOTAN LIZARD (SQUAMATA, ANGUIMORPHA) FROM THE LATEST CRETACEOUS (MAASTRICHTIAN) OF NORTH AMERICA

**B145** **G. Varnham**, **F. Kyalo Manthi**, **J.J. Head** RE-EXAMINATION OF *VARANUS RUSINGENSIS* (SQUAMATA: VARANIDAE) FROM THE MIOCENE OF KENYA: IMPLICATIONS FOR THE EVOLUTIONARY HISTORY OF *VARANUS* IN AFRICA

**B146** **L. Hanning**, **C. Zak**, **J. McCartney**, **M. Lamanna**, **B.S. Salem**, **H. El-Saka**, **S. El-Sayed**, **H.M. Sallam** NEW MATERIAL OF THE EARLY SNAKE *SIMOLIOPHIS* (OPHIDIA, SIMOLIOPHIIDAE) FROM THE UPPER CRETACEOUS BAHARIYA FORMATION OF EGYPT

**B147** **T. Maho**, **R. Reisz** EXCEPTIONALLY RAPID TOOTH DEVELOPMENT AND ONTOGENETIC CHANGES IN THE FEEDING APPARATUS OF THE KOMODO DRAGON

**B148** **P.I. Heise** A NEW ANGUIMORPH FROM THE HELL CREEK FORMATION WITH POTENTIAL AFFINITIES TO THE SHINISAURIA

**B149** **M.F. Greaves** TESTING MORPHOLOGICAL CORRELATES TO ECOLOGICAL SPECIALIZATIONS IN SQUAMATES: INNER EAR SIZE ADAPTATIONS TO DIFFERENT HABITATS

**B150** **R.K. Denton** FIRST RECORD OF A TERRESTRIAL SNAKE (CF. *THAMNOPHIS* SP.) FROM THE CALVERT FORMATION (EARLY BARSTOVIAN, MIDDLE MIOCENE) OF MARYLAND, AND THE EARLIEST KNOWN OCCURENCE OF THE NATRICINE GENUS *THAMNOPHIS* IN NORTH AMERICA

**B151** **J. McCartney**, **T. Grover**, **A. Montalvo**, **K. Roman**, **C. Mtelela**, **E.M. Roberts**, **N.J. Stevens** VERTEBRAL FUSION IN A COLUBRIFORM SNAKE FROM THE LATE OLIGOCENE RUKWA RIFT BASIN, SOUTHWESTERN TANZANIA

**B152** **E.T. Metz**, **P.S. Druckenmiller** AN ARTICULATED POLYCOTYLID POSTCRANIUM (*DOLICHORHYNCHOPS* SP.) FROM THE BEARPAW SHALE (UPPER CRETACEOUS) OF MONTANA

**B153** **A.C. Pritchard**, **B.T. Kligman**, **P.E. Olsen**, **M. Stevens**, **H. Sues**, **L. Treado**, **R. Weems**, **P. LeTourneau** A NEW VERTEBRATE-BEARING LOCALITY FROM THE CARNIAN (LATE TRIASSIC) OF VIRGINIA (NEWARK SUPERGROUP, TAYLORSVILLE BASIN)

**B154** **C. Carter**, **L.J. Rose**, **A.B. Heckert**, **B. Lauer**, **R. Lauer** TAPHONOMY AND PRESERVATION BIAS OF MICROVERTEBRATE BODY FOSSILS AT THE REVUELTIAN HOMESTEAD SITE (UPPER TRIASSIC: NORIAN), GARITA CREEK FORMATION OF EAST-CENTRAL NEW MEXICO, USA

**B155** **E.D. Mooney**, **T. Maho**, **J. Bevitt**, **R. Reisz** EXCEPTIONAL PRESERVATION OF CARTILAGINOUS ELEMENTS IN AN EARLY CAPTORHINID REPTILE AND NEW INSIGHTS INTO EVOLUTION OF THE STERNUM AND COSTAL RESPIRATION

**B156** **C.M. Fenstermaker**, **D. Meyer**, **Z.S. Morris** A NEW NEARLY COMPLETE EARLY SQUAMATE FROM THE UPPER JURASSIC, MORRISON FORMATION

**B157** **S.C. Steely**, **J. Pirlo**, **M. Riegler**, **L. Vinola Lopez**, **J.R. Bourque**, **R. Hulbert**, **J.I. Bloch** NEW ALLIGATOR (*ALLIGATOR* SP.) FOSSIL FINDINGS DEMONSTRATE A CHANGE IN LIMB MORPHOLOGY OVER THE LAST 18 MILLION YEARS

**B158** **A. Sanchez** NEW INFORMATION ON APPENDICULAR ELEMENTS AND ONTOGENTIC LIFE STAGES OF BASAL CAPTORHINID REPTILES: ADDITIONAL JUVENILE POSTCRANIAL SKELETAL REMAINS OF THE EARLY PERMIAN EUREPTILIAN REPTILE *LABIDOSAURUS*

**B159** **R. Rogers**, **K. Myhran**, **L.N. Weaver**, **K. Curry Rogers**, **T. Tobin**, **G. Wilson Mantilla** A COMPARATIVE TAPHONOMIC ANALYSIS OF THE BUG CREEK ANTHILLS, A MIXED CRETACEOUS–PALEOGENE MICROFOSSIL BONEBED FROM NORTHEASTERN MONTANA

**B160** **A. Koelewijn**, **V. Krapovickas** FOSSILGAITSIM: A SIMULATION FRAMEWORK FOR GAIT OF EXTINCT QUADRUPED ANIMALS

**B161** **A. Woodruff**, **C. Walton** NEW RECORDS AND INTERPRETATIONS OF THE LATE-CENOZOIC PALEOCOMMUNITY OF THE HAILE 22A SITE OF ALACHUA COUNTY, FLORIDA

**B162** **A.D. Apgar**, **C. Tomé**, **J.R. Moore** ASSESSING ECOLOGICAL RELATIONSHIPS AND STRUCTURES AMONG LATE TRIASSIC VERTEBRATES IN PETRIFIED FOREST NATIONAL PARK

**B163** **A.L. Wurtz**, **J.P. Crothers**, **R. Dunn**, **C. Carter**, **A.B. Heckert**, **J.R. Foster**, **R.K. Hunt-Foster**, **J.J. Eberle** REBECCA'S HOLLOW: A FRESHWATER MICROVERTEBRATE ASSEMBLAGE FROM THE UPPER CRETACEOUS (EDMONTONIAN) WILLIAMS FORK FORMATION, NORTHWESTERN COLORADO, USA

**B164** **C.P. Bohus**, **J. Pardo** A COLOSTIED FROM THE EARLY PENNSYLVANIAN OF ARKANSAS

**B165** **T. Nolan** COMPARATIVE VERTEBRAL MORPHOLOGY AND INTERVERTEBRAL MOBILITY OF *SEYMOURIA*

**B166** **J.C. Heidenfelder**, **A.B. Heckert**, **I. Pugh**, **S.J. Nesbitt**, **R. Lauer**, **B. Lauer** THE MORPHOLOGY OF TANYSTROPHEIDS (REPTILIA ARCHOSAUROMORPHA) OF THE UPPER TRIASSIC (REVUELTIAN EARLY-MID NORIAN) HOMESTEAD SITE IN EAST CENTRAL NEW MEXICO

**B167** **G.S. Goncalves**, **C.A. Sidor** THE PRESENCE OF A NEW DREPANOSAUROMORPH CLAW MORPHOTYPE FROM THE CHINLE FORMATION

**B168** **D. Havlat**, **K.M. Jenkins**, **B.T. Kligman** MORPHOLOGY, MINERALOGY, AND IMPLICATIONS OF VERTEBRATE COPROLITES FROM THE LATE TRIASSIC CHINLE FORMATION OF ARIZONA

**B169** **J.R. Moore**, **Y. Sarubbi Jacks**, **R. Souberlich**, **D.J. Varricchio** MODERN VERTEBRATE TAPHONOMY ON THE PILCOMAYO DISTRIBUTIVE FLUVIAL SYSTEM IN PARAGUAY AS A MODEL FOR THE TERRESTRIAL FOSSIL RECORD

**B170** **J.N. Crouch**, **C. Carter**, **A.B. Heckert**, **B. Lauer**, **R. Lauer** PRELIMINARY TAPHONOMY OF A REVUELTIAN (UPPER TRIASSIC: NORIAN) AGE COPROLITE ASSEMBLAGE FROM THE HOMESTEAD SITE IN THE GARITA CREEK FORMATION, EAST-CENTRAL NEW MEXICO, USA.

**FRIDAY MORNING, OCTOBER 20, 2023**
**TECHNICAL SESSION 10: EUARCHONTOGLIRES & XENARTHRA**
**MEETING ROOM JUNIOR BALLROOM A/B**
**MODERATORS: Dorien de Vries and Francesca Socki**

**8:00** **L. Schroeder**, **M. Lang**, **C. López Aguirre**, **G. San Martin Flores**, **O. Bertrand**, **M.T. Silcox** VARIATION IN ENDOCRANIAL SHAPE ALLOMETRY WITHIN EUARCHONTOGLIRES

**8:15** **J.P. Hunter**, **N. Schottenstein**, **J. Jernvall** CROWN TYPES REVISITED: PATTERNS OF PHENOTYPIC DIVERSITY IN THE LOWER DENTITION OF PALEOGENE PRIMATES AND PLESIADAPIFORMS

**8:30** **M.T. Silcox**, **K.R. Selig**, **T. Williamson**, **M. Schillaci** A NEW GENUS AND SPECIES OF NOTHARCTINE PRIMATE (ADAPOIDEA) FROM THE EARLY EOCENE OF THE SAN JUAN BASIN, NEW MEXICO

**8:45** **K.P. McNulty**, **R. Jansma**, **T. Imfeld**, **T. Lehmann**, **L. Michel**, **S. Muteti**, **D.J. Peppe** NEW FOSSIL APE SPECIMENS FROM RUSINGA ISLAND, KENYA, AND THEIR IMPLICATIONS FOR THE EVOLUTION OF HOMINOIDEA

**9:00** **E.C. Kirk**, **R.H. Dunn**, **B. Rodwell**, **K.B. Townsend** NEW *OURAYIA* AND *MYTONIUS* (PRIMATES, OMOMYOIDEA) FROM THE TORNILLO BASIN OF TEXAS

**9:15** **D. de Vries**, **R. Batista**, **J. Maugoust**, **J. Boubli**, **I. Goodhead**, **R.M. Beck** RECONSTRUCTION OF DIETARY EVOLUTION IN NEW WORLD PRIMATES (PLATYRRHINI) BASED ON DENTAL TOPOGRAPHIC ANALYSIS OF EXTANT AND FOSSIL SPECIES

**9:30** **R.F. Kay**, **K. Allen**, **M.S. Bargo**, **E.C. Kirk**, **P.E. Morse**, **C. Organ**, **S.F. Vizcaino** ENDOCASTS OF *HOMUNCULUS PATAGONICUS* (PRIMATES, PLATYRRHINI) DEMONSTRATE THAT ANTHROPOID-LIKE NEOCORTICAL PROPORTIONS WERE ESTABLISHED BEFORE THE EVOLUTION OF SUBSTANTIAL BRAIN SIZE ENLARGEMENT IN PLATYRRHINES

**9:45** **J.X. Samuels**, **J.J. Calède**, **K.E. Bredehoeft** ANATOMY AND PALEOECOLOGY OF THE WORLD'S LARGEST SQUIRREL (SCIURIDAE), THE GIANT MARMOT *PAENEMARMOTA BARBOURI*

**10:15** **A.K. Hensley**, **B.E. Crowley**, **L.W. Viñola-López**, **S.B. Cooke** PUTTING THE "WHO" IN HUTIA: A COMPREHENSIVE ISOTOPIC EVALUATION OF HISPANIOLA'S RECENTLY EXTINCT RODENTS

**10:30** **S.S. Strassberg**, **K.D. Angielczyk** DIGGING INTO THE PAST: INFERENCE OF FOSSORIALITY AND DIGGING MODE IN FOSSIL RODENTS USING EXTANT FOSSORS AS A GUIDE

**10:45** **F. Socki**, **J.J. Calède**, **D.L. Fox** EVOLUTIONARY INTEGRATION AND THE FOSSIL RECORD: UTILIZING PROXIES FOR SPECIALIZATION TO INFER TRAIT COVARIATION IN GEOMORPHA (ORDER: RODENTIA)

**11:00** **E. Restrepo-Cortes**, **J.S. Keller**, **K. Lyons**, **F.A. Smith** OLD PROBLEMS REQUIRE MODERN SOLUTIONS: 3D TOOTH TRAITS UNVEIL *REITHRODONTOMYS* SPECIES PALEOECOLOGY

**11:15** **T.R. Pansani**, **M. Dantas**, **L. Asevedo**, **H.I. de Araújo-Júnior**, **P. Gueriau**, **M. Thoury**, **L. Bertrand**, **A.K. Behrensmeyer**, **B. Pobiner** PALEOMETRY APPLIED TO TAPHONOMY: EVIDENCE FOR AN ANTHROPOGENICALLY MODIFIED GROUND SLOTH TOOTH FROM THE LATE PLEISTOCENE OF THE BRAZILIAN INTERTROPICAL REGION

**11:30** **R.J. Haupt**, **M.T. Clementz**, **H. McDonald** NEW RADIOCARBON DATES FOR SHASTA GROUND SLOTH (*NOTHROTHERIOPS SHASTENSIS*) DUNG FROM GYPSUM CAVE, NV, SHOW POTENTIALLY EARLIER INHABITATION AND PROVIDE ADDITIONAL CONTEXT FOR PALEOECOLOGICAL INTERPRETATION

**11:45** **R.K. McAfee**, **S. Beery**, **M. Macias**, **J. Almonte** NEW EVIDENCE FOR SLOTH FAMILY UNITS IN *PAROCNUS* (MAMMALIA: PILOSA) FROM LATE QUATERNARY CAVE SYSTEMS IN HISPANIOLA (DOMINICAN REPUBLIC, HAITI)

**12:00** **E. Zack**, **S.M. Smith**, **K.D. Angielczyk** HOLE IN TWO: DESCRIBING THE BASIVERTEBRAL FORAMINA IN PILOSA

## FRIDAY MORNING, OCTOBER 20, 2023
## TECHNICAL SESSION 11: ARCHOSAURS
## MEETING ROOM JUNIOR BALLROOM C
## MODERATORS: Atrayee Haldar and Aubrey Roberts

**8:00** **B. Slibeck**, **A. Milner**, **P.E. Olsen** EARLY DINOSAUR-DOMINATED COMMUNITIES FROM HIGH-RELIEF, SHALLOW, LAKE MARGIN ENVIRONMENTS IN LOW-LATITUDES (LATE TRIASSIC – EARLY JURASSIC, NEW JERSEY AND UTAH, USA)

**8:15** **J. Stiegler**, **A.B. Heckert** A NEW HYPOTHESIS FOR EARLY DINOSAUR DIVERGENCES INFORMED BY SPECIMENS FROM THE UPPER TRIASSIC (REVUELTIAN: NORIAN) SNYDER QUARRY OF NORTHERN NEW MEXICO, U.S.A.

**8:30** **R.B. Sookias**, **L. Pradelli**, **E. Ascarrunz**, **D. Silvestro**, **M. Ezcurra** “EARLY BURSTS” OF SPECIATION, NO EFFECT OF BODY SIZE, AND POTENTIALLY CRYPTIC DIVERSIFICATION REVEALED BY BAYESIAN OCCURRENCE-BASED APPROACHES DURING THE TRIASSIC ARCHOSAUROMORPH RADIATION

**8:45** **E. Keeble**, **A. Fitch**, **D. Foffa**, **V. Paes Neto**, **W.G. Parker**, **W. Reyes**, **S.J. Nesbitt** QUANTIFYING THE SHAPE OF THE TEETH OF A RARE HERBIVOROUS CLADE OF ARCHOSAURS IN THE TRIASSIC USING 3D GEOMETRIC MORPHOMETRICS AND DISCRETE ANALYSIS

**9:00** **B.R. Peecook**, **K.D. Angielczyk**, **J. Museba**, **S.J. Nesbitt**, **C.A. Sidor**, **R.M. Smith**, **S. Tolan**, **P. Viglietti**, **M. Whitney** THE OPAQUE MIDDLE TRIASSIC ASSEMBLAGES OF THE LUANGWA BASIN (ZAMBIA), WITH A NEW ARMORED ARCHOSAUR OCCURRENCE

**9:15** **A.J. Roberts**, **D. Foffa**, **B. Kear**, **J. Hurum** NEW ARCHOSAURIFORM RECORDS FROM THE MARINE EARLY TRIASSIC OF SVALBARD

**9:30** **H. Sues**, **R.R. Schoch** NEW ARCHOSAUROMORPH REPTILES FROM THE UPPER BUNTSANDSTEIN (MIDDLE TRIASSIC: ANISIAN) OF GERMANY: NEW EVIDENCE ON TETRAPOD DIVERSIFICATION IN LAURASIA FOLLOWING THE END-PERMIAN EXTINCTION

**9:45** **W. Foster**, **P. Gensbigler**, **J.D. Wilson**, **T. Lyson**, **G.S. Bever** A NEW LOOK AT THE CRANIAL ANATOMY OF THE EARLY TRIASSIC RHYNCHOSAUR *MESOSUCHUS BROWNI*, WITH COMMENTS ON OLFACTORY EVOLUTION IN REPTILES

**10:15** **A.D. Cornille**, **F. Witzmann**, **P. Asbach**, **E. Wolff**, **F. Clarac** EXTANT CROCODILIAN BONE PATHOLOGIES AS A WINDOW TO PHYTOSAUR PALEOPATHOLOGY

**10:30** **E.R. Goldsmith**, **S.J. Nesbitt**, **M.R. Stocker** COMPARISON OF CRANIAL AND POSTCRANIAL ONTOGENY IN A SIZE SERIES OF ‘*REDONDASAURUS*’ (ARCHOSAURIFORMES: PHYTOSAURIA)

**10:45** **A. Haldar**, **S. Ray** ENIGMATIC ARCHOSAURIAN (DIAPSIDA, ARCHOSAURIA) OSTEODERMS FROM THE UPPER TRIASSIC OF INDIA

**11:00** **E. Patellos**, **N.D. Smith**, **D. Bottjer** THE POTENTIAL OF UNASSUMING FOSSILS: ASSESSING THE TAXONOMIC UTILITY OF OSTEODERM MORPHOLOGY.

**11:15** **E. Armour Smith**, **C.A. Sidor** INSIGHTS INTO SHUVOSAURID (PSEUDOSUCHIA: POPOSAUROIDEA) ANATOMICAL VARIATION INFERRED FROM A NEW TAXON FROM THE UPPER TRIASSIC CHINLE FORMATION OF PETRIFIED FOREST NATIONAL PARK

**11:30 D.M. Unwin, J. Bestwick, R. Smyth** ONTOGENETIC NICHE PARTITIONING IN PTEROSAURS – ECOLOGICAL AND EVOLUTIONARY IMPLICATIONS

**11:45 W.L. Parsons, K.M. Parsons** A PARTIAL PTEROSAUR EGG CONTAINING AN EMBRYONIC SKULL, NECK, SHOULDER, PARTIAL FORELIMB, AND SOME FOSSILIZED SOFT TISSUES FROM THE EARLY CRETACEOUS CLOVERLY FORMATION OF CENTRAL MONTANA

**12:00 I. Perea, E. Wolff, J.R. Moore** ASSESSING THE PTEROMORTEM POSE IN BIRDS, BATS, AND PTEROSAURS

**FRIDAY MORNING, OCTOBER 20, 2023**
**TECHNICAL SESSION 12: METHODS & PALEOHISTORY**
**MEETING ROOM JUNIOR BALLROOM D**
**MODERATORS: Mateusz Wosik and Congyu Yu**

**8:00 P.C. Sereno, R.P. DeVries, N.P. Myhrvold, S.L. Baumgart, D. Vidal, T. Keillor, L.L. Conroy** *FOSSILSCOPE*: LIFTING THE VEIL ON THE UNDERLYING DATA AND MANIPULATIONS YIELDING 3-DIMENSIONAL SKELETAL AND FLESH MODELS

**8:15 C. Yu, Z. Qin** APPLY ARTIFICIAL INTELLIGENCE IN PALEONTOLOGY: HISTORY, PROGRESS, AND PERSPECTIVES

**8:30 D. Rhoda, K.D. Angielczyk** MULTIVARIATE ADAPTIVE LANDSCAPES WITH QUADRATIC REGRESSION

**8:45 E. Huang, G.S. Bever** STATE SPACE MISSPECIFICATION IN LIKELIHOOD-BASED PHYLOGENETIC ANALYSIS OF MORPHOLOGY AND ITS IMPACT ON TREE TOPOLOGY

**9:00 A.K. Behrensmeyer, K.M. Stewart** BONE CONCENTRATIONS UNDER ISOLATED TREES AS A MODEL FOR TIME-AVERAGED, SPECIES-RICH FOSSIL ASSEMBLAGES

**9:15 R. Laker** TAPHONOMIC VARIATION AT MULTIPLE SCALES: TRENDS OF OCCURRENCE, MACRO- AND MICROSCOPIC CONDITION VARY PREDICTABLY ACROSS FACIES AND ALONG SURFACES OF NONDEPOSITION AND EROSION

**9:30 M.J. Powers, R. Nydam, M.W. Caldwell** THE LION, THE GOAT, THE SNAKE AND A HERO: DEFEATING CHIMERAS USING THE "BELLEROPHON METHOD"

**9:45 J. Meachen, W. Binder, S. Campbell, J. Cohen, L. DeSantis, R. Dunn, E. Lindsey, J.H. Miller, F.R. O'Keefe, J. Southon** RANCHO LA BREA IS THE PITS: A HIGH-RESOLUTION CHRONOLOGY OF MEGAFAUNAL ENTRAPMENT ACROSS THE LAST 49,000 YEARS

**10:15 M.D. D'Emic** DETERMINANTS OF DENTINE GROWTH RATES ACROSS AMNIOTA

**10:30 Y. Ke, R. Pei, X. Xu** DENTAL HISTOLOGY AND CT DATA OF EARLY CRETACEOUS *DILONG PARADOXUS* SHED LIGHT ON TYRANNOSAUROID TOOTH REPLACEMENT EVOLUTION

**10:45 M. Wosik** RETRODEFORMATION OF OSTEOHISTOLOGICAL THIN-SECTIONS

**11:00 N.P. Myhrvold, P.C. Sereno, S.L. Baumgart, D. Vidal, F.E. Fish, D. Henderson, E.T. Saitta** DEEP DIVE ON BONE COMPACTNESS AND STATISTICAL METHODS FOR RECOGNIZING SIGNIFICANCE IN THE INFERENCE OF LIFESTYLE IN SPINOSAURIDS AND OTHER DINOSAURS

**11:15 S. Bijl, P. Tafforeau, P. Ahlberg, A. Clement, P. Bishop, J. Clack, S. Sanchez** UNEXPECTED DISCREPANCY BETWEEN BONE MICROANATOMY AND PRESUMED LIFESTYLE REVEALED IN CARBONIFEROUS TETRAPODS

**11:30 C.W. Garros, M.J. Powers, A.D. Dyer, P.J. Currie** OSTEOHISTOLOGY OF TROODONTID METATARSALS FROM THE DINOSAUR PARK FORMATION (DPF): IMPLICATIONS FOR GROWTH, STRESS, AND UNDERSTANDING OF PATHOLOGY

**11:45 W.J. Freimuth, B.P. Hedrick, C. Liao, L.E. Zanno** COMPARATIVE OSTEOHISTOLOGY OF THERIZINOSAURIA: IMPLICATIONS FOR THE EVOLUTION OF LARGE SIZE IN HERBIVOROUS THEROPODS

**12:00 Q. Li, J. Liu, N. Klein, Y. Nakajima, P. Sander** BONE HISTOLOGY REVEALS PUBERTY IN A MESOZOIC REPTILE

**FRIDAY AFTERNOON, OCTOBER 20, 2023**
**TECHNICAL SESSION 13: FISHES - ACTINOPTERYGIANS**
**MEETING ROOM JUNIOR BALLROOM A/B**
**MODERATORS: Juan Liu and Jacob Wilson**

**1:45** **R.T. Figueroa**, **M. Friedman** INTEGRATING FOSSIL AND EXTANT DATA IN ORDER TO UNDERSTAND PATTERNS OF RAY-FINNED FISH BRAIN EVOLUTION

**2:00** **J. Stack**, **M.R. Stocker** A LATE PENNSYLVANIAN (MISSOURIAN) RAY-FINNED FISH (ACTINOPTERYGII) EVOLVED A MOBILE MAXILLA INDEPENDENTLY OF EXTANT CLADES

**2:15** **J. Liu**, **J. Marcé-Nogué**, **J. Hoeflich** SENSE AND SENSIBILITY: ESTIMATING AND COMPARING THE HEARING CAPABILITY OF OTOPHYSAN FISH USING DYNAMIC FINITE ELEMENT METHODS

**2:30** **A. Caron**, **M. Coates** DEEP KNOWLEDGE: INSIGHTS FROM THE POST-CRANIAL ENDOSKELETON OF *CHIRODUS GRANULOSUM*

**2:45** **T. Miyashita** COMPARATIVE PHYLOGENETICS OF EARLY ACTINOPTERYGIAN FISHES

**3:00** **M. Friedman**, **R.T. Figueroa**, **R. Shell**, **D. Peterman**, **C. Ciampaglio** A NEW ACTINOPTERYGIAN FISH FROM THE MISSISSIPPIAN (SERPUKHOVIAN) OF ALABAMA CLARIFIES THE ANATOMY AND RELATIONSHIPS OF THE ENIGMATIC FAMILY PAPHOSISCIDAE

**3:15** **S. Maden**, **J.X. Samuels** THE EARLY FOSSIL RECORD OF FRESHWATER FISH IN APPALACHIA IS REVEALED BY A NEW EARLY PLIOCENE ASSEMBLAGE FROM THE GRAY FOSSIL SITE (TENNESSEE, USA)

**3:30** **J.D. Wilson**, **E. Huang**, **T. Lyson**, **G.S. Bever** FRESHWATER FISH AND THE CRETACEOUS/PALEOGENE BOUNDARY: A CRITICAL, INTEGRATIVE ASSESSMENT OF SURVIVORSHIP PATTERNS

**3:45** **J. Liston**, **A.E. Maltese** 'I'M NOT LIKE THE OTHER GILLS': REEVALUATION AND REIDENTIFICATION OF *PLATYLITHOPHYCUS* SPECIMENS FROM THE NIOBRARA OF WESTERN KANSAS

**4:00** **A. Lanzetti**, **R. Dearden**, **A.S. Jones**, **S. Giles**, **S. Lautenschlager**, **Z. Johanson**, **E. Randle**, **I.J. Sansom** NO JAWS? NO PROBLEM. MORPHOLOGICAL DIVERSITY IN THE FEEDING APPARATUS OF HETEROSTRACANS JAWLESS "FISHES" (AGNATHA: HETEROSTRACI)

**FRIDAY AFTERNOON, OCTOBER 20, 2023**
**TECHNICAL SESSION 14: CROCODYLOMORPHS & TURTLES**
**MEETING ROOM JUNIOR BALLROOM C**
**MODERATORS: Eric Wilberg and Clinton Grand Pre**

**1:45** **E. Wilberg**, **P.L. Godoy**, **A.H. Turner**, **J.B. Smaers** MODELING EVOLUTIONARY TRANSITIONS IN THE CROCODYLIFORM FEEDING APPARATUS

**2:00** **D. Gunnin**, **B.W. Schubert**, **H. N. Woodward** OSTEOHISTOLOGY OF A LARGE SAMPLE OF *ALLIGATOR MISSISSIPPIENSIS* PROVIDES A FOUNDATION FOR INTERPRETING GROWTH IN *ALLIGATOR* FROM THE EARLY PLIOCENE GRAY FOSSIL SITE

**2:15** **C.A. Grand Pre**, **W. Thielicke**, **R. Diaz**, **B.P. Hedrick**, **R.M. Elsey**, **E.R. Schachner** THE FUNCTIONAL RELATIONSHIP BETWEEN AXIAL SKELETON MORPHOLOGY AND PLEURAL DISPLACEMENT IN THE AMERICAN ALLIGATOR (*ALLIGATOR MISSISSIPPIENSIS)*: VALIDATING AN OSTEOLOGICAL CORRELATE FOR THE HEPATIC PISTON IN CROCODYLOMORPHA

**2:30** **P.M. Burke**, **P.D. Mannion** NEUROANATOMICAL FEATURES HELP ELUCIDATE THE EVOLUTIONARY HISTORY OF GAVIALOID CROCODYLIANS

**2:45** **M. Margulis-Ohnuma**, **A.A. Ruebenstahl**, **B.S. Bhullar** A NEW CROCODYLOMORPH FROM THE CARNIAN GHOST RANCH FORMATION WITH IMPLICATIONS FOR THE SOLIDOCRANIAN GHOST LINEAGE

**3:00** **B.S. Salem**, **M. Lamanna**, **P.M. O'Connor**, **W.A. Thabet**, **S. El-Sayed**, **H.M. Sallam** A PEIROSAURID CROCODYLIFORM FROM THE UPPER CRETACEOUS (CENOMANIAN) BAHARIYA FORMATION OF THE BAHARIYA OASIS, WESTERN DESERT, EGYPT

**3:15** **E. Lessner**, **H. Petermann**, **T. Lyson** NEW MATERIAL FROM THE LOWER PALEOCENE (EARLY DANIAN) DENVER BASIN FILL GAPS IN THE PERSISTENT RECORD OF EUSUCHIA (CROCODYLOMORPHA) AFTER THE CRETACEOUS–PALEOGENE MASS EXTINCTION

**3:30** **A.K. Hastings**, **B.W. Schubert** NEW DWARF SPECIES OF *ALLIGATOR* FROM THE EARLY MIOCENE OF FLORIDA (USA)

**3:45** **N.S. Ong**, **H. N. Woodward** USING SURFACE TOPOGRAPHIC ANALYSIS AND PALEOHISTOLOGY TO TRACK THE EVOLUTION OF THE METAPLASTIC LAPPET IN K/PG PAN-TRIONYCHIDS

**4:00** **J.R. Lively**, **A.L. Titus**, **K. Knoll**, **C.A. Suarez**, **D. Yamamura**, **A.G. Kirkpatrick** A FRESHWATER PANCHELONIOID TURTLE FROM THE KAIPAROWITS FORMATION (UPPER CRETACEOUS: CAMPANIAN) OF GRAND STAIRCASE-ESCALANTE NATIONAL MONUMENT, UTAH

**FRIDAY AFTERNOON, OCTOBER 20, 2023**
**TECHNICAL SESSION 15: PALEOECOLOGY & PALEOCLIMATOLOGY**
**MEETING ROOM JUNIOR BALLROOM D**
**MODERATORS: Nathaniel Morley and Celina Suarez**

**1:45** **D. Foffa**, **S.J. Nesbitt**, **M.R. Stocker**, **B.T. Kligman**, **A.D. Marsh**, **W.G. Parker**, **R. Butler** ECOLOGICAL RECOVERY AND DIVERSIFICATION OF EARLY MESOZOIC, LOW LATITUDE VERTEBRATE ASSEMBLAGES

**2:00** **V. Trinidad**, **D. Munyikwa**, **M. Zondo**, **T. Broderick**, **S.J. Nesbitt**, **C. Griffin** TESTING TRIASSIC CLIMATE VARIABILITY AND VERTEBRATE DISTRIBUTION ACROSS SOUTHERN PANGEA DURING THE TRIASSIC WITH COMPARATIVE HISTOLOGICAL ANALYSIS

**2:15** **C.A. Suarez**, **J. Choiniere**, **E. Bordy**, **G. Sharman**, **D. Oberg**, **B. Howard** LIGHT STABLE ISOTOPE GEOCHEMISTRY OF UPPER TRIASSIC TO LOWER JURASSIC VERTEBRATES FROM THE ELLIOT FORMATION OF SOUTHERN AFRICA

**2:30** **B. Linzmeier**, **S. Hartman**, **D.M. Lovelace** COLD CASE #201MA: LATE TRIASSIC TRANSIENT COLD PHASE EXPLAINS TERRESTRIAL TAXONOMIC SELECTIVITY DURING THE END TRIASSIC EXTINCTION

**2:45** **P.E. Olsen**, **B.T. Kligman**, **J. Villari**, **B. Slibeck**, **K. Hughes**, **A.C. Pritchard** LATEST TRIASSIC AND EARLY JURASSIC CONTINENTAL VERTEBRATE ASSEMBLAGES OF THE CULPEPER RIFT BASIN (VIRGINIA, USA) IN HIGH-RESOLUTION TEMPORAL AND ENVIRONMENTAL PERSPECTIVES

**3:00** **D.W. Krause**, **B. Rakotozafy**, **H. Randrianaly**, **P.M. O'Connor** THIRTY YEARS OF COLLABORATIVE VERTEBRATE PALEONTOLOGY: THE MAHAJANGA BASIN PROJECT (LATE CRETACEOUS, MADAGASCAR)

**3:15** **N.E. Morley**, **L.R. Leighton**, **E.B. Koppelhus**, **P.J. Currie** A MULTIVARIATE COMPARISON OF INLAND AND COASTAL VERTEBRATE COMMUNITIES FROM THE LATEST CAMPANIAN OF ALBERTA, CANADA WITH IMPLICATIONS FOR VERTEBRATE BIOGEOGRAPHY

**3:30** **S.C. Lechki**, **R.B. Benson** EXPLORING REPRODUCTIVE OUTPUT ALLOMETRY AND POTENTIAL GROWTH AND MAINTENANCE TRADE-OFFS ACROSS EXTANT TETRAPOD GROUPS: A COMPARISON WITH NON-AVIAN DINOSAURS

**3:45** **R. Naprstek**, **T. Lyson**, **P. Hunt**, **V. Burhoe**, **G. Peyrat**, **R. Giammasi**, **D.E. Fastovsky** DAWN OF THE CENOZOIC: POST-DINOSAUR-EXTINCTION PALEOENVIRONMENTS OF CORRAL BLUFFS, CO, USA

**4:00** **B. Burger** EOCENE FOREST COMMUNITIES AND THE EXTINCTION OF MULTITUBERCULATE MAMMALS

**FRIDAY AFTERNOON, OCTOBER 20, 2023**
**EDUCATION AND OUTREACH POSTER SESSION**
**MEETING ROOM GRAND BALLROOM B**
**Authors must be present from 4:30 – 6:30 p.m. on Friday, October 20**

**B171** **M.J. Powers**, **G. Bradley** SPECIATE: A NOVEL METHOD FOR TEACHING PALEOGEOGRAPHY AND SPECIATION IN A BLENDED DELIVERY UNDERGRADUATE PALAEONTOLOGY COURSE

**B172** **B.J. MacFadden**, **P. Antonenko**, **V. Perez**, **J. Waisome**, **B. Abramowitz**, **S. Killingsworth**, **D. Parnell** FOSSIL SHARK TEETH ACTIVATE ENGAGEMENT AND LEARNING ABOUT AI (ARTIFICIAL INTELLIGENCE) IN FLORIDA PUBLIC MIDDLE SCHOOLS

**B173** **K.L. Whitman**, **A. Marron**, **M.R. Borths** THE EPIC JOURNEY OF PRIMATES: BUILDING A NEW EXHIBIT AND TOUR AT THE DUKE LEMUR CENTER MUSEUM OF NATURAL HISTORY

**B174** **D. Sharma**, **S. Killingsworth**, **J. Bokor**, **J. Pirlo**, **B. Abramowitz**, **B.J. MacFadden** CHEWING ON CHANGE: TRAINING THE NEXT GENERATION OF SCIENCE COMMUNICATORS

**B175** **I.K. Lundeen**, **K.M. Melstrom** STUDENT ENGAGEMENT THROUGH COLLABORATIVE FIELD ANATOMICAL AND TAXONOMIC GUIDES

**B176** **A.A. Brink** UTILIZING AN INTERNAL GRANT TO SUPPORT GENDER EQUITY IN THE GEOSCIENCES AT THE UNIVERSITY OF SOUTHERN MISSISSIPPI

**B177** **A.E. Hall**, **C. Hogan**, **S.A. Williams**, **C. Dobbs** THE DESIGN AND CONSTRUCTION OF A NEW VIRTUAL OUTREACH STUDIO AT MUSEUM OF THE ROCKIES

**B178** **S. Boessenecker**, **R. Boessenecker** THE SKULL CHALLENGE: AN OUTREACH ACTIVITY TEACHING VISITORS ABOUT ANATOMY AND HOW PALEONTOLOGISTS IDENTIFY AND INTERPRET THE BONES THEY FIND

**B179** **M.F. Bonnan** ONCE UPON DEEP TIME: USING MUSIC AND ART TO COMMUNICATE EVOLUTION TO EVERYONE

**B180** **S.M. Lukowski**, **K.M. Smith** DIFFERENTIATED OUTREACH STRATEGIES FOR RURAL AND URBAN ENVIRONMENTS TO PROMOTE LEARNING, EQUITY, AND INCLUSION

**B181** **L.E. Wilson**, **K. Link**, **K. O'Dell**, **T.W. Moore** ASSESSING AND IMPROVING SCIENCE STUDENT #SCICOMM SKILLS

**B182** **A.M. Mychajliw**, **S. Steil**, **G. Santos**, **G. Pask** THE POKÉMON POP-UP MUSEUM: SUPPORTING STUDENT LEARNING THROUGH SPECIMEN-BASED COMMUNITY OUTREACH AT A SMALL LIBERAL ARTS COLLEGE

**B183** **H.N. Thomas**, **D. Humphries**, **M.C. Dickson** BIAS IN DOCUMENTARY PORTRAYALS OF PALEONTOLOGY AND PREHISTORIC LIFE

**B184** **E.D. Jones**, **J. Kanipe**, **H.M. Avrahami**, **T. Cullen**, **L.E. Zanno** ASSESSING MIDDLE SCHOOL STUDENT ACCURACY IN IDENTIFYING VERTEBRATE MICROFOSSILS FROM THE UPPER CRETACEOUS HELL CREEK FORMATION

**B185** **B. Pobiner**, **J. Olsson**, **M. Rivers**, **A.K. Behrensmeyer**, **G. Delia**, **K. Dean**, **R. Potts**, **J. Clark** INCREASING ACCESSIBILITY TO PALEONTOLOGY-RELATED EXHIBITS AT THE SMITHSONIAN'S NATIONAL MUSEUM OF NATURAL HISTORY

**B186** **A.K. Hastings**, **J. Groenert**, **C.M. Early**, **J. Holm**, **E. Stallnick** HAPPY CROCTOBER! DEVELOPING CROCODILE-THEMED 'LEARN FROM HOME' CONTENT AND ADAPTING IT INTO IN-PERSON EDUCATION PROGRAMMING

**B187** **C.N. Simon**, **R.K. Hunt-Foster**, **C. Snyder** INSPIRING THE FUTURE QUEENS OF PALEONTOLOGY

**B188** **S.A. Williams**, **J. Mathews**, **K.M. Tremaine** AN EXEMPLAR IN SCIENCE EDUCATION: 25 YEARS OF PALEOFEST AND COUNTING

**FRIDAY AFTERNOON, OCTOBER 20, 2023**
**REGULAR POSTER SESSION 3**
**MEETING ROOM GRAND BALLROOM B**
**Authors must be present from 4:30 – 6:30 p.m. on Friday, October 20**

**B189** **A.W. Peng**, **S. Hopkins** DEMOGRAPHIC DIVERSITY AMONG JOURNAL OF VERTEBRATE PALEONTOLOGY FIRST AUTHORS BASED ON PALEONTOLOGICAL SUBFIELD

**B190** **K. Shimada**, **Y. Yamaoka**, **Y. Kurihara**, **Y. Takakuwa**, **H.M. Maisch**, **M.A. Becker**, **R.A. Eagle**, **M.L. Griffiths** PLACOID SCALES OF THE NEOGENE MEGATOOTH SHARK, *OTODUS MEGALODON* (LAMNIFORMES: OTODONTIDAE), AND THEIR BIOLOGICAL IMPLICATIONS

**B191** **V. Perez**, **S. Groff**, **M. Hintermeister**, **B.J. MacFadden** EXPLORATION OF FREE WEB-BASED MACHINE LEARNING PLATFORMS FOR PALEONTOLOGY APPLICATIONS

**B192** **J.M. Hodnet**, **R. Toomey**, **R. Olson**, **J. Tweet**, **V. Santucci** A NEW JANASSID PETALODONT (CHONDRICHTHYES, PETALODONTIFORMES, JANASSIDAE) FROM THE MIDDLE MISSISSIPPIAN (VISÈAN) STE. GENVIEVE FORMATION FROM MAMMOTH CAVE NATIONAL PARK, KENTUCKY, USA

**B193** **A.G. Armagno**, **K. Shimada** STRATIGRAPHIC OCCURRENCES OF THE CRETACEOUS SHARK GENUS *CRETODUS* (LAMNIFORMES: PSEUDOSCAPANORHYNCHIDAE) IN KANSAS, USA, AND THEIR ECOLOGICAL IMPLICATIONS

**B194** **N. Gardner**, **M. Bovis**, **R. Engelman**, **C. Godlesky**, **J.M. Hodnet**, **R. Shell** NEW OCCURRENCES OF LATE CARBONIFEROUS FOSSIL FISHES FROM WEST VIRGINIA, APPALACHIAN BASIN, U.S.A.

**B195** **D.A. Cline**, **R. Shell**, **J. Cheshire**, **C. Ciampaglio**, **L. Fuelling** CHONDRICHTHYANS AND OSTEICHTHYANS OF THE SKELLEY LIMESTONE (CONEMAUGH GROUP: CARBONIFEROUS, GZHELIAN) OF OHIO

**B196** **H.C. Egli**, **J.M. Hodnet** AN ENIGMATIC MARINE XENACANTH (CHONDRICHTHYES, ELASMOBRANCHII, XENACANTHIMORPHA) FROM THE LATE MISSISSIPPIAN (SERPUKHOVIAN) BANGOR LIMESTONE OF NORTHWEST ALABAMA, USA

**B197** **R. Geiser**, **R. Shell**, **J. Thomas**, **M. Davis** VERTEBRATE BIODIVERSITY IN THE LASALLE LIMESTONE (CARBONIFEROUS: PENNSYLVANIAN) OF THE AMERICAN MIDCONTINENT

**B198** **R. Shell**, **D.A. Cline**, **J. Cheshire**, **C. Ciampaglio**, **L. Fuelling** A MARINE VERTEBRATE FAUNA OF THE LOWER BRUSH CREEK LIMESTONE (CONEMAUGH GROUP: CARBONIFEROUS, GZHELIAN) OF OHIO

**B199** **C. Ciampaglio**, **D.A. Cline**, **R. Shell**, **L. Fuelling** CHONDRICHTHYAN FAUNA OF THE CARBONIFEROUS-PERMIAN BOUNDARY (COUNCIL GROVE GROUP, RED EAGLE LIMESTONE) OF KANSAS

**B200** **W.O. Kornfeld**, **E.M. Simpson**, **M.R. Borths** EXAMINING DIETARY DIVERSITY IN A PALEOGENE HYRAX (AFROTHERIA, MAMMALIA) FAUNA FROM THE FAYUM DEPRESSION, EGYPT USING MESOWEAR ANALYSIS

**B201** **W.J. Sanders**, **M. Kirinya Muthuri**, **L.N. Leakey**, **M.G. Leakey**, **T. Gichunge Ibui**, **P. Mbete Mbatha** A NEW, DIVERSE FOSSIL ELEPHANT ASSEMBLAGE FROM MID-PLIOCENE ESHOA, KENYA, INCLUDING THE FIRST SUB-SAHARAN MAMMOTH SKULL

**B202** **K.M. Smith**, **B.E. Stoneburg**, **A.C. Dooley**, **A.C. Dooley** TUSK MORPHOLOGY AND SEXUAL DIMORPHISM IN THE PACIFIC MASTODON (*MAMMUT PACIFICUS*)

**B203** **M. Harrington**, **C. Widga** ISOTOPIC ANALYSIS AND MOBILITY MAPPING OF COLUMBIAN MAMMOTHS (*MAMMUTHUS COLUMBI*) FROM THE MAMMOTH SITE IN SOUTH DAKOTA

**B204** **D.K. Butler**, **L.T. Yann**, **D.J. Peppe** EVIDENCE OF OSTEOLOGICAL PATHOLOGIES IN LATE PLEISTOCENE COLUMBIAN MAMMOTHS (*MAMMUTHUS COLUMBI*) AT WACO MAMMOTH NATIONAL MONUMENT, WACO, TEXAS, USA

**B205** **C. Widga**, **M. Harrington**, **D.A. Esker** MAMMOTH MOBILITY AND LANDSCAPE USE: A REGIONAL META-ANALYSIS

**B206** **M.M. Yard**, **L.T. Yann**, **S. Forman** USING EXTANT *LOXODONTA AFRICANA* AGE CORRELATIONS TO DESCRIBE AN EXTINCT *MAMMUTHUS COLUMBI* ASSEMBLAGE AND MORTALITY FROM WACO MAMMOTH NATIONAL MONUMENT (WACO, TEXAS)

**B207** **M.U. Tablizo**, **G.D. van den Bergh**, **A.S. Fernando** ON THE VALIDITY OF *STEGODON LUZONENSIS*

**B208** **C.D. White** PARTIAL CRANIUM AND ASSOCIATED TUSKS OF MIO-PLIOCENE *MAMMUT* (MAMMALIA, PROBOSCIDEA) FROM PASCAGOULA FORMATION IN TUNICA HILLS, LOUISIANA

**B209** **C.A. Barrett**, **M.I. Pardi**, **E. Mueller - Filipes**, **L. DeSantis** MAMMOTH VS. ELEPHANT: INSIGHTS INTO DIETARY VARIABILITY THROUGH TIME

**B210** **A.M. Joshi**, **M. Tanksale**, **R. Poojari**, **S. Chopra**, **A. Srinivas**, **R. Patnaik**, **P. Sukumaran**, **A. Kaur**, **A. Deshpande**, **T. Padhan**, **V. Singh**, **P. Chauhan** A NEW ASSEMBLAGE OF PROBOSCIDEAN FOSSILS FROM CENTRAL INDIA AND ASSOCIATED STRATIGRAPHIC AND TAPHONOMIC OBSERVATIONS

**B211** **A.M. Pamfilie**, **A. Byran**, **N.S. Vitek** TRENDS IN CRANIODENTAL MORPHOLOGY IN THE AMERICAN MINK (*NEOGALE VISON*)

**B212** **D. R. Ramoni** FOSSIL CANIDS FROM VENEZUELA

**B213** **A.E. Nelson** *CANIS RUFUS* HAS CHANGED SIGNIFICANTLY SINCE THE IMPLEMENTATION OF THE CAPTIVE BREEDING PROGRAM, AND BOTH MORPHOTYPES ARE SIGNIFICANTLY DIFFERENT FROM NON-EASTERN *CANIS LUPUS* AND *CANIS LATRANS*

**B214** **S. Lopezalles** THE SHAPE OF SPEED: THE RELATIONSHIP BETWEEN 3D HUMERUS SHAPE AND MAXIMUM RUNNING SPEED

**B215** **I. Brown**, **T. Clarke**, **D. Vick**, **M. Lawing**, **L. Siciliano-Martina** CARNASSIAL RELATIVE BLADE LENGTH (RBL) AS AN INDICATOR OF CARNIVORAN DIETARY ECOLOGY

**B216** **L. Werdelin**, **T. Flink**, **J. Van Der Hoek** CONVOLUTED HISTORY OF A COLLECTION: FOSSIL CARNIVORA FROM QUERCY, FRANCE IN THE SWEDISH MUSEUM OF NATURAL HISTORY

**B217** **J.A. Pérez-Claros**, **B. Figueirido** MORPHOLOGICAL ADAPTATION OF THE DENTITION IN THE ORDER CARNIVORA INVOLVES GREATER TRANSFORMATIONS IN THE UPPER DENTITION THAN IN THE LOWER DENTITION

**B218** **C.J. Salcido**, **P.D. Polly** CAN YOU EAT WELL IN FLATLAND? A CASE STUDY ON WHEN TWO-DIMENSIONAL GEOMETRIC MORPHOMETRIC ANALYSIS IS SUFFICIENT FOR THE FUNCTIONAL MORPHOLOGICAL ANALYSIS AND EVOLUTION OF "FLAT" BIOLOGICAL SHAPES

**B219** **C. XU**, **J. Wei**, **L. DeSantis** DIETARY VARIABILITY IN *LYNX RUFUS* FROM THE PLEISTOCENE TO THE PRESENT

**B220** **S. Johnson**, **R. Feranec**, **J.R. Pardo**, **J. Southon**, **L. DeSantis** COLLAGEN- AND CARBONATE-DERIVED CARBON ISOTOPES OF CANIDS AND FELIDS FROM C3 DOMINANT ECOSYSTEMS IN NORTH AMERICA: INVESTIGATING TISSUE SPECIFIC DIFFERENCES

**B221** **S.F. Al-Ashqar**, **M. Borths**, **E. Sieffert**, **S. El-Sayed**, **H.M. Sallam** NEW DENTAL REMAINS OF A LARGE TERATODONTINE (HYAINAILOURIDAE, MAMMALIA) FROM THE LATE EOCENE OF THE FAYUM DEPRESSION, EGYPT

**B222** **G.W. Flora** BECOMING GIANT: THE EVOLUTION OF BODY SIZE IN UINTATHERES

**B223** **T. Harper**, **G.W. Rougier** NON-UNIFORM DISTRIBUTION OF COCHLEAR FIBERS IN THE CRETACEOUS MERIDIOLESTIDAN *CRONOPIO*

**B224** **J.J. Eberle**, **G.M. Erickson**, **X. Munoz**, **P.S. Druckenmiller** NEW PEDIOMYID METATHERIANS FROM THE PRINCE CREEK FORMATION – IMPLICATIONS FOR MAMMALIAN COLONIZATION IN THE LATE CRETACEOUS PALEO-ARCTIC, NORTHERN ALASKA

**B225** **C. Trenbeath**, **J.J. Eberle** SMALL SURVIVORS: PUERCAN METATHERIAN SPECIMENS FROM THE WESTERN INTERIOR

**B226** **T.C. Wheat**, **J.A. Case** DIETARY NICHES OF THE POSSUM FAMILIES (MARSUPIALIA) PRESENT IN THE ETADUNNA FORMATION OF SOUTH AUSTRALIA

**B227** **S.L. Damico**, **F. Anaya**, **D.A. Croft** ENCEPHALIZATION QUOTIENT (EQ) OF A MIDDLE MIOCENE SPARASSODONT (METATHERIA) FROM BOLIVIA

**B228** **J.A. Case**, **G.W. Rougier**, **Z. Luo**, **M. Lamanna** FIRST UPPER MOLAR OF THE LATEST OLIGOCENE PLATYPUS *OBDURODON INSIGNIS* CASTS LIGHT ON DENTAL EVOLUTION IN THE ORNITHORHYCHIDAE (MONOTREMATA).

**B229** **L. Hall**, **S. Brusatte**, **T. Williamson** THE PNEUMATIC SINUSES OF THE TYRANNOSAUROID *BISTAHIEVERSOR SEALEYI*

**B230** **T.M. Kantelis**, **R. Carney** AN ANALYSIS OF *ARCHAEOPTERYX*'S DENTAL MORPHOLOGY VIA GEOMETRIC MORPHOMETRICS

**B231** **R.S. Sombathy**, **M.D. D'Emic**, **P.M. O'Connor** OSTEOHISTOLOGY OF THE THEROPOD DINOSAUR *CERATOSAURUS*

**B232** **D.K. Smith** AN INITIAL DYNAMIC MODEL OF LOCOMOTION FOR THE THERIZINOSAUR *NOTHRONYCHUS GRAFFAMI* (THEROPODA, MANIRAPTORA)

**B233** **P. Rhynard**, **M. Stricklin**, **R. Ridgely**, **L.M. Witmer** INSIDE AN ICON: NEW INFORMATION ON THE SKULL AND RELATED ANATOMY OF THE *ALLOSAURUS JIMMADSENI* (DINOSAURIA: THEROPODA) SPECIMEN KNOWN AS "BIG AL" (MOR 693) BASED ON NEW CT SCANNING

**B234** **T. Oswald**, **B. Curtice** THE DRAGONS OF CEDAR MOUNTAIN: SHED TEETH INDICATE THE PRESENCE OF ONE OR MORE LARGE ALLOSAUROIDS FROM THE YELLOW CAT MEMBER OF THE CEDAR MOUNTAIN FORMATION

**B235** **J.E. Bugos**, **S.N. McDavid** JUVENILE SKULLS OF *COELOPHYSIS BAURI* FROM GHOST RANCH, NEW MEXICO

**B236** **R. Davila**, **J. O'Connor**, **Y. Ma**, **C. Sullivan** THREE-DIMENSIONAL RANGE OF MOTION ANALYSIS IN *TYRANNOSAURUS REX* FORELIMB

**B237** **M. Stricklin**, **P. Rhynard**, **R. Ridgely**, **L.M. Witmer** MORE TROUBLE FOR BIG AL: REPORT OF THE FIRST CRANIOFACIAL LESION IN THE PATHOLOGY-RIDDEN SPECIMEN OF *ALLOSAURUS JIMMADSENI* (DINOSAURIA: THEROPODA) KNOWN AS "BIG AL" (MOR 693)

**B238** **J.T. Voris**, **D.K. Zelenitsky**, **F. Therrien**, **M.J. Powers**, **P.J. Currie** EUDROMAEOSAURIAN FRONTALS POTENTIALLY REFERRABLE TO *ATROCIRAPTOR MARSHALLI* (DROMAEOSAURIDAE: SAURORNITHOLESTINAE) FROM THE UPPER CRETACEOUS (UPPERMOST CAMPANIAN-MAASTRICHTIAN) HORSESHOE CANYON FORMATION OF ALBERTA, CANADA SUGGEST A PREDATOR WITH A ROBUST SKULL

**B239** **C. Morrison**, **P.D. Mannion**, **L. Porro**, **P. Barrett** A TYRANNOSAUROID BRAINCASE FROM THE EARLY CRETACEOUS OF THE ISLE OF WIGHT (U.K.) AND ITS IMPLICATIONS FOR THEROPOD EVOLUTION AND DIVERSITY

**B240** **Y. Yamazaki**, **Y. Inada**, **K. Kakuta** EVALUATION OF THE AERODYNAMIC PERFORMANCE OF *ANCHIORNIS HUXLEY* USING ITS HINDLIMBS AS WINGS

**B241** **H. Inaba**, **R. Matsumoto**, **K. Chiba**, **T. Okoshi**, **R. Takasaki**, **K. Murakami**, **M. Saneyoshi**, **H. Tsujigiwa**, **B. Mainbayar**, **K. Tsogtbaatar** NEW REPORT OF OSTEOSARCOMA IN A MULTI-INDIVIDUAL DINOSAUR ASSEMBLAGE AND ITS PALEOECOLOGICAL IMPLICATIONS

**B242** **J.A. McLarty**, **R.E. Clawson**, **R. Esperante** STOP AND TURN BEHAVIOR OF THEROPODS INDICATED BY TRACKWAYS AT THE CARRERAS PAMPA TRACKSITE

**B243** **A.V. Moore**, **W.J. Freimuth**, **L.E. Zanno** INVESTIGATING PATTERNS OF NEUROCENTRAL SUTURE FUSION IN THE EARLY-DIVERGING THERIZINOSAURIAN *FALCARIUS UTAHENSIS*

**B244** **R. Takasaki**, **K. Chiba**, **M. Ichikawa**, **T. Tanaka**, **K. Tsogtbaatar**, **D. Evans** AN INTRAMANDIBULAR JOINT IN TROODONTIDS AND ITS FUNCTIONAL IMPLICATIONS

**B245** **Z.R. Perry**, **P.S. Druckenmiller**, **G.M. Erickson** A REANALYSIS OF THE ARCTIC TYRANNOSAURID *NANUQSAURUS HOGLUNDI* FROM THE UPPER CRETACEOUS PRINCE CREEK FORMATION, NORTHERN ALASKA

**SATURDAY MORNING, OCTOBER 21, 2023**
**TECHNICAL SESSION 16: THEROPODS – I**
**MEETING ROOM JUNIOR BALLROOM A/B**
**MODERATORS: Pasha van Bijlert and Nicholas Longrich**

**8:00** **C. Coppock**, **M.J. Powers**, **P.J. Currie** DIVERSITY AND DISTRIBUTION OF *DASPLETOSAURUS* MAXILLARY MORPHOTYPES EXCEEDS KNOWN SPECIES DIVERSITY

**8:15** **N.R. Longrich**, **S. Dalman**, **M. Loewen**, **R. Pyron**, **S.E. Jasinski**, **D. Malinzak**, **S. Lucas**, **A. Fiorillo**, **P.J. Currie** A GIANT TYRANNOSAUR FROM THE CAMPANIAN-MAASTRICHTIAN OF SOUTHERN NORTH AMERICA AND THE ORIGINS OF *TYRANNOSAURUS*

**8:30** **T.L. Adams**, **R.S. Tykoski**, **S.K. Drumheller**, **H. N. Woodward** TYRANNOSAURID HINDLIMB FROM THE JAVELINA FORMATION (LATE CRETACEOUS, MAASTRICHTIAN) OF BIG BEND NATIONAL PARK, TEXAS

**8:45** **T. Carr**, **S. Brusatte** *DASPLETOSAURUS WILSONI* (THEROPODA, TYRANNOSAURIDAE) IS A SUBJECTIVE JUNIOR SYNONYM OF *D. TOROSUS*; *DASPLETOSAURUS* IS THE SISTER CLADE, NOT A PARAPHYLETIC GRADE, OF THE *TYRANNOSAURUS* LINE OF DESCENT

**9:00** **J. Slowiak-Morkovina**, **S. Brusatte**, **T. Szczygielski** *BAGARAATAN*, OSMÓLSKA'S UNUSUAL THEROPOD DINOSAUR FROM THE NEMEGT FORMATION OF MONGOLIA PROVIDES NEW DATA ON THE EARLY ONTOGENY OF TYRANNOSAURIDS

**9:15** **P.A. van Bijlert**, **K.T. Bates**, **A. van Soest**, **A.S. Schulp** MUSCULOSKELETAL CONSTRAINTS ON TOP SPEED OF *TYRANNOSAURUS REX* EXPLORED USING 3D PHYSICS SIMULATIONS

**9:30** **T.C. Wyenberg-Henzler**, **D.C. D'Amore**, **C. Sullivan** TOOTH USE AND WEAR IN CARNIVOROUS REPTILES, AND IMPLICATIONS FOR TYRANNOSAURID FEEDING BEHAVIOR

**9:45** **P. Makovicky**, **R. Cifelli**, **L.E. Zanno**, **T. Cullen** NEW ADDITIONS TO THE EARLY FOSSIL RECORD OF CAENAGNATHIDS IN NORTH AMERICA

**10:15** **M. Serio**, **D.J. Varricchio** FIRST DIGITAL FORELIMB RECONSTRUCTION AND RANGE OF MOTION ASSESSMENT OF THE LATE CRETACEOUS DINOSAUR *TROODON FORMOSUS*: NEW RESULTS

**10:30** **H.R. Boekenheide**, **D.J. Varricchio**, **J. Scannella**, **M.T. Carrano** SIZE VARIATION, INCREASED BODY MASS ESTIMATES, AND POTENTIAL SEXUAL DIMORPHISM IN CAMPANIAN THEROPOD *TROODON FORMOSUS*

**10:45** **M. Lamanna**, **J. Porfiri**, **M. Baiano**, **D. dos Santos**, **F. Gianechini**, **J.A. Case** NEW INSIGHTS INTO UNENLAGIINE (THEROPODA: PARAVES: DROMAEOSAURIDAE) DIVERSITY, PALEOECOLOGY, AND PALEOBIOGEOGRAPHY DERIVED FROM LATE CRETACEOUS FOSSILS FROM PATAGONIA AND ANTARCTICA

**11:00** **A.A. Ruebenstahl**, **M.J. Powers**, **J.G. Napoli**, **T. Chinzorig**, **A.H. Turner**, **B.S. Bhullar**, **M.A. Norell** MULTIPLE UNRECOGNIZED SPECIES OF *VELOCIRAPTOR* IN THE *VELOCIRAPTOR MONGOLIENSIS* SPECIES COMPLEX

**11:15** **A.J. Nye**, **B. Britt**, **R. Scheetz** HINDLIMB ALLOMETRY IN *UTAHRAPTOR OSTROMMAYSI* (THEROPODA: DROMAEOSAURIDAE) AND IMPLICATIONS FOR ONTOGENETIC SHIFTS IN PREDATION STRATEGIES AND NICHE PARTITIONING

**11:30** **H.M. Maddox**, **C.A. Boyd**, **S.K. Drumheller** A NEW DROMAEOSAURID FROM THE HELL CREEK FORMATION (MAASTRITCHIAN) OF NORTH DAKOTA WITH POSSIBLE TIES TO THE CLADE UNENLAGIINIA

**11:45** **C.J. Hohman**, **D.J. Varricchio**, **J.G. Napoli**, **A.T. McDonald** A REVISION OF THE DROMAEOSAURIDS OF THE CRETACEOUS (CAMPANIAN) TWO MEDICINE FORMATION OF MONTANA, U.S.A.

**12:00** **WITHDRAWN**

**SATURDAY MORNING, OCTOBER 21, 2023**
**TECHNICAL SESSION 17: AFROTHERIA & MAMMAL MACROEVOLUTION**
**MEETING ROOM JUNIOR BALLROOM C**
**MODERATORS: Danielle Fraser and Ethan Shirley**

**8:00** **E.M. Simpson**, **B.E. Crowley**, **M.R. Borths**, **J.N. Leichliter**, **H.B. Vonhof**, **T. Lüdecke** STABLE ISOTOPES CONFIRM NICHE PARTITIONING AMONG MORPHOLOGICALLY DIVERSE PALEOGENE HYRAXES (HYRACOIDEA; PLIOHYRACIDAE) FROM THE FAYUM, EGYPT

**8:15** **K. Beard**, **K. Miller**, **K.L. Rust**, **F. Ocakoglu**, **P. Coster**, **A. Licht**, **G. Métais** NEW DATA ON THE EARLY EVOLUTIONARY HISTORY OF BALKANATOLIAN EMBRITHOPODA (MAMMALIA, PAENUNGULATA) FROM THE ÇIÇEKDAĞI BASIN, CENTRAL ANATOLIA

**8:30** **M.D. Cherney**, **D.C. Fisher**, **R. Auchus**, **A.N. Rountrey**, **E.A. Shirley**, **P. Selcer**, **D. Mol**, **G. Boeskorov**, **S. Vartanyan**, **A. Tikhonov** PIONEERING PROBOSCIDEAN PALEOENDOCRINOLOGY: HORMONES IN TUSKS SHED LIGHT ON WOOLLY MAMMOTH MATING BEHAVIOR

**8:45** **D. Yang**, **G. Bowen**, **K. Uno**, **K. Podkovyroff**, **N. Carpenter**, **D.P. Fernandez**, **T.E. Cerling** A NEW MODEL OF STRONTIUM ISOTOPE TURNOVER PROVIDES QUANTITATIVE RECONSTRUCTIONS OF STRONTIUM INTAKE FOR PALEO-MIGRATION STUDIES OF PROBOSCIDEANS

**9:00** **A.M. Jukar** A POSSIBLE NEW MAMMUTID FROM THE HAGERMAN FOSSIL BEDS

**9:15** **E.A. Shirley**, **D.C. Fisher** MAMMOTH POPULATION MODELS: IMPLICATIONS FOR PALEOBIOLOGY AND CONSERVATION

**9:30** **D. Grossnickle**, **S. Hellert**, **R. Ely**, **G. Slater**, **G. Lloyd**, **K.D. Angielczyk**, **A. Bormet**, **G. Wilson Mantilla** SMALL MAMMALS IN A LARGE TREE: EXAMINING THE TIMING OF THE EARLY THERIAN RADIATION USING A NOVEL PHYLOGENETIC METATREE

**9:45** **D. Fraser**, **M.A. Balk**, **J.R. Doby**, **S. Hopkins**, **S. Pineda-Munoz**, **D. Reuter**, **A. Shupinski**, **A. Villasenor**, **K.F. Emery**, **F. FuTRES** APPROXIMATING MAMMAL FUNCTIONAL TRAIT DIVERSITY USING BODY MASS

**10:15** **N.S. Vitek**, **E. Saks**, **A. Dong**, **D.L. Ward**, **E. Pomeroy**, **M. Martin-Gronert**, **S.E. Ozanne** MAMMALIAN MOLAR SIZE CAN CHANGE SIGNIFICANTLY WITHOUT EVOLVING: IMPLICATIONS OF LAB NUTRITION STUDIES FOR INTERPRETING THE FOSSIL RECORD

**10:30** **I. Magallanes**, **P. Li**, **T. Martin**, **Z. Luo** EXPLORING THE FUNCTIONAL SIGNIFICANCE OF TOOTH ROOT SHAPE, SIZE, AND ORIENTATION IN MODERN TRIBOSPHENIC MAMMALS AND JURASSIC CLADOTHERIANS

**10:45** **H.E. Smith**, **M. Morley**, **C. McAdams**, **J. Zaim**, **A. -**, **M. Puspaningrum**, **A. Trihascaryo**, **G.J. Price**, **J. Louys** A MICROMORPHOLOGICAL PERSPECTIVE ON TAPHONOMY IN THE COMPLEX FOSSIL-BEARING CAVES OF WEST SUMATRA

**11:00** **G.S. Pizzini**, **L.N. Weaver**, **C. Badgley**, **J. Downey**, **R. Rogers**, **S.G. Chester**, **T. Lyson** TAPHONOMY OF LATEST CRETACEOUS-EARLIEST PALEOCENE FOSSIL LOCALITIES FROM THE DENVER FORMATION OF COLORADO REVEALS THE IMPORTANCE OF MOUNTAIN PROXIMITY IN THE FORMATION, PRODUCTIVITY, AND TAXONOMIC MAKEUP OF VERTEBRATE MICROFOSSIL BONEBEDS

**11:15** **G.J. Davidson** A TAXONOMIC REVIEW AND CHRONOLOGIC CORRELATION OF THE FOSSIL ASSEMBLAGE FROM THE MISSION PIT LOCALITY (CLARENDONIAN), SOUTH DAKOTA

**11:30** **L.N. Weaver**, **C. Badgley** ON THE ROLE OF TECTONICS AND CLIMATE IN STIMULATING THE CRETACEOUS DIVERSIFICATION OF MAMMALS

**11:45** **D.A. Croft**, **O. Adojoh**, **F. Anaya**, **R. Engelman**, **M. Galarza**, **N.E. Levin**, **B.Z. Saylor** NEW PALEONTOLOGICAL AND GEOLOGICAL DATA FROM THE MIDDLE MIOCENE OF NAZARENO, SOUTHERN BOLIVIA

**12:00** **B.E. Carter**, **J. Alroy** IMPACTS OF PLEISTOCENE EXTINCTIONS ON LOCAL MAMMAL ASSEMBLAGES AROUND THE WORLD

**SATURDAY MORNING, OCTOBER 21, 2023**
**TECHNICAL SESSION 18: SYNAPSIDS**
**MEETING ROOM JUNIOR BALLROOM D**
**MODERATORS: Henry Thomas and Anna Brant**

**8:00** **A. Mann**, **R.W. Hook**, **S.E. Pierce** FIRST CRANIAL REMAINS OF THE OPHIACODONTID "*CLEPSYDROPS*" FROM THE UPPER CARBONIFEROUS OF LINTON, OHIO, AND THE DEPOSITS'S PRECOCIOUS AMNIOTE RECORD

**8:15** **J.K. Lungmus** QUALITATIVE AND QUANTITATIVE DATA COMBINATIONS REVEAL UNIQUE PATTERNS IN THE POST-CRANIAL ANATOMY AND TAXONOMY OF SPHENACODONTIDAE (SYNAPSIDA: SPHENACODONTIDAE)

**8:30** **S.S. Sumida**, **A. Huttenlocker** A COLLECTION OF JUVENILE SYNAPSID POSTCRANIAL MATERIAL FROM THE EARLY PERMIAN CLEAR FORK FORMATION CRADDOCK RANCH AND ITS BEARING ON OUR UNDERSTANDING OF ASTRAGALUS FORMATION IN BASAL AMNIOTES

**8:45** **J. Pardo**, **K.D. Angielczyk** PARTIAL AND COMPLETE SECONDARY PALATES OF SCINCID LIZARDS: AN ANALOG FOR NON-MAMMALIAN SYNAPSIDS?

**9:00** **H.N. Thomas**, **K.D. Angielczyk**, **B.R. Peecook** THE RETURN OF GEIKIIDAE (SYNAPSIDA: DICYNODONTIA) TO THE UPPER MADUMABISA MUDSTONE FORMATION (UPPER PERMIAN) OF THE LUANGWA BASIN, ZAMBIA

**9:15** **C.A. Sidor**, **A. Mann**, **C.F. Kammerer**, **F. Levy**, **K.D. Angielczyk**, **J. Museba**, **B.R. Peecook**, **R.M. Smith**, **S. Tolan**, **P. Viglietti** GORGONOPSIANS FROM THE PERMIAN OF ZAMBIA: PRELIMINARY DATA FROM THE LUANGWA AND MID-ZAMBEZI BASINS.

**9:30** **K.D. Angielczyk**, **C.A. Sidor**, **S. Tolan**, **R.M. Smith**, **N. Barbolini**, **C.V. Beightol**, **J. Museba**, **S.J. Nesbitt**, **J.S. Steyer**, **N.J. Tabor** THE GEOGRAPHIC AND STRATIGRAPHIC DISTRIBUTIONS OF PERMIAN DICYNODONTS (THERAPSIDA, ANOMODONTIA) IN THE MID-ZAMBEZI BASIN, ZAMBIA: ESTABLISHING A BASELINE FOR FUTURE RESEARCH

**9:45** **WITHDRAWN**

**10:15** **H. George**, **N. Larkin** A NEW NON-STAHLECKERIID KANNEMEYERIIFORM DICYNODONT FROM THE MANDA BEDS OF TANZANIA ASSOCIATED WITH STRONGLY CURVED CLAWS PROVIDES INSIGHT INTO NICHE PARTITIONING AMONG DICYNODONTS AND BIOTIC INTERCHANGE BETWEEN SOUTHERN AFRICA AND SOUTH AMERICA DURING THE MIDDLE TRIASSIC

**10:30** **M. Whitney**, **K.D. Angielczyk**, **A. Huttenlocker** BONE HISTOLOGY OF *SPHENACODON* (SYNAPSIDA: PELYCOSAURIA) PROVIDES INSIGHT INTO THE 'PELYCOSAUR'-THERAPSID TRANSITION

**10:45** **C.P. Abbott** SQUISHING THE SQUISHED: THE EFFECTS OF TAPHONOMIC DEFORMATION AND WEATHERING ON THE INTERPRETATION OF TAXONOMIC VARIATION IN SPECIES OF *LYSTROSAURUS* (ANOMODONTIA) IN THE KAROO BASIN, SOUTH AFRICA

**11:00** **J. Rawson**, **P. Gill**, **A. Martinelli**, **M. Soares**, **C. Schultz**, **E. Rayfield** 3D ANATOMY OF THE CRANIOMANDIBULAR JOINT OF DERIVED SOUTH AMERICAN CYNODONTS AND HOMOPLASY IN THE EVOLUTION OF THE MAMMALIAN JAW

**11:15** **C.F. Kammerer**, **L.C. Pusch**, **H. Sues** CRANIAL ANATOMY AND PALEOBIOLOGY OF AN ABUNDANT TRAVERSODONTID CYNODONT FROM THE LATE TRIASSIC OF EASTERN NORTH AMERICA

**11:30** **L.A. Norton**, **J. Benoit**, **F. Abdala** DETERMINING CANINE REPLACEMENT IN THE SMALLEST INDIVIDUALS OF *THRINAXODON LIORHINUS* (THERAPSIDA, CYNODONTIA) USING X-RAY MICRO-COMPUTED TOMOGRAPHY

**11:45** **A. Milner**, **A.D. Marsh**, **H. Sues**, **J.C. Buchwitz**, **H.A. Carter**, **V. Santucci** PRELIMINARY REPORT OF TRITYLODONTID BONEBEDS IN THE LOWER JURASSIC KAYENTA-NAVAJO TRANSITION (GLEN CANYON GROUP) AT GLEN CANYON NATIONAL RECREATION AREA, UTAH

**12:00** **A. Brant**, **C.A. Sidor** EARLIEST OCCURRENCE OF AN INOSTRANCEVIID GORGONOPSIAN IN SOUTHERN PANGEA: PRELIMINARY DATA FROM THE USILI FORMATION OF TANZANIA

**SATURDAY AFTERNOON, OCTOBER 21, 2023**
**TECHNICAL SESSION 19: THEROPODS – II**
**MEETING ROOM JUNIOR BALLROOM A/B**
**MODERATORS: María Ciudad Real Ballestero and Jamese Napoli**

**1:45** **R.E. Clawson**, **J.A. McLarty**, **R. Esperante** UPPER CRETACEOUS (MAASTRICHTIAN) THEROPOD SWIM TRACES IN BOLIVIA AND THEIR BEHAVIORAL AND PALEOENVIRONMENTAL SIGNIFICANCE

**2:00** **M.T. Carrano** NEW INFORMATION ON THEROPOD MATERIALS FROM THE LOWER CRETACEOUS ARUNDEL CLAY OF MARYLAND

**2:15** **M. Ciudad Real Ballestero**, **D. Vidal**, **P.C. Sereno** COMPARATIVE NEUROANATOMY OF “MID CRETACEOUS” APEX PREDATORY DINOSAURS OF AFRICA SUPPORTS NICHE PARTITION

**2:30** **D.W. Larson**, **A. Verstraete**, **D. Evans**, **K. Brink** EVALUATING HETERODONTY USING THE ENAMEL MICROSTRUCTURES OF SMALL THEROPOD DINOSAURS

**2:45** **D.C. D'Amore**, **D. Hone**, **E.D. Johnson-Ransom**, **E. Snively** SPINOSAURIDS CONVERGE WITH EXTANT CROCODYLIAN GENERALISTS IN TOOTH VARIABILITY: AN ANALYSIS OF HETERODONTY IN AQUATIC FORAGERS THROUGH ALVEOLAR DIMENSIONS.

**3:00** **E.D. Johnson-Ransom**, **E. Snively**, **P.C. Sereno**, **C. Ross** FINITE ELEMENT ANALYSIS OF FEEDING FUNCTION IN THE SKULL OF *SPINOSAURUS*

**3:15** **E. Warner-Cowgill**, **M. Loewen**, **G.W. Storrs**, **M. Lamanna** NEW INFORMATION ON THE CRANIAL ANATOMY OF *TORVOSAURUS* (THEROPODA: MEGALOSAURIDAE) FROM THE UPPER JURASSIC MORRISON FORMATION

**3:30** **C. Boisvert**, **J. Perkins**, **B. Curtice** TALES OF STRONG JAWS, ENIGMATIC PASTS, AND TINY FORELIMBS: A TEMPORAL-SPATIAL LOOK INTO FIVE CLADES CONTAINING CARNIVOROUS MEGATHEROPODS AND THEIR DIVERSITY ACROSS THE LATTER MESOZOIC ERA

**3:45** **Y. Kobayashi**, **T. Chinzorig**, **R. Takasaki**, **A. Fiorillo**, **K. Chiba**, **M. Saneyoshi**, **S. Ishigaki** THE NORTHERNMOST OCCURRENCE OF A DEINOCHEIRID ORNITHOMIMOSAUR FROM MONTANA (UPPER CRETACEOUS, JUDITH RIVER FORMATION): ITS PALEOBIOGEOGRAPHIC AND BIODIVERSITY SIGNIFICANCE

**4:00** **J.G. Napoli**, **M.J. Powers**, **A.A. Ruebenstahl**, **J.T. Voris**, **T.L. Green**, **A.H. Turner**, **J.J. Flynn**, **P.J. Currie**, **M.A. Norell** CRYPTIC SPECIES IN THE THEROPOD FOSSIL RECORD

**SATURDAY AFTERNOON, OCTOBER 21, 2023**
**TECHNICAL SESSION 20: MARINE MAMMALS & BATS**
**MEETING ROOM JUNIOR BALLROOM C**
**MODERATORS: Fernando Araujo Perini and Nickolas Brand**

**1:45** **M.M. Harvell**, **N. Kohno** A NEARLY COMPLETE SKELETON OF THE STELLER'S SEA COW (*HYDRODAMALIS GIGAS* (ZIMMERMAN, 1780)) FROM THE LOWER PLEISTOCENE OF JAPAN REVEALS SOME ANATOMICAL CHARACTERISTICS

**2:00** **J.P. Rule**, **T. Park**, **J.W. Adams**, **A. Evans**, **H. Richards**, **P. Scofield**, **J. Buckeridge**, **E.M. Fitzgerald** AN ARCHAIC SOUTHERN TRUE SEAL (SUBFAMILY MONACHINAE) FROM THE LATE NEOGENE OF NEW ZEALAND REVEALS THE ORIGIN OF HIGH FREQUENCY HEARING IN PHOCIDAE

**2:15** **A. Spiess**, **A.M. Mychajliw**, **O.L. Olson**, **B. Newsom**, **C. Abin**, **K.S. Hughes**, **V. Paige**, **L. Parker**, **L.S. Snyderman**, **D. Soctomah**, **S. Turvey**, **L. Welch**, **S. Williams**, **T. Rick**, **C.A. Hofman** A GHOST ON THE COAST: MORPHOLOGICAL, ISOTOPIC, AND GENOMIC INSIGHT INTO THE EXTINCTION OF THE SEA MINK (*NEOGALE MACRODON*)

**2:30** **A.S. Gohar**, **M.S. Antar**, **S. El-Sayed**, **H.M. Sallam** NEW JUVENILE BASILOSAURID WHALE MATERIALS FROM THE LATE EOCENE OF EGYPT PROVIDE CLUES ON DEVELOPMENTAL PATTERNS IN STEM CETACEA

**2:45** **N.A. Brand**, **M.D. Nelson**, **C.M. Peredo**, **M.D. Uhen** SHARING A MORPHOSPACE: USING ELLIPTIC FOURIER ANALYSIS TO (NOT) IDENTIFY HETERODONT CETACEAN CHEEK TEETH

**3:00** **M.D. Nelson** SYSTEMATIC REVISION OF WASTEBASKET TAXA REFINES HYPOTHESES OF KEY EVOLUTIONARY TRANSITIONS: A CASE STUDY OF THE SQUALODONTIDAE (CETACEA)

**3:15** **R. Boessenecker**, **J.H. Geisler** EXTREME DIVERSITY OF SPEAR-TOOTHED, WAIPATIID-GRADE DOLPHINS (CETACEA:ODONTOCETI) FROM THE OLIGOCENE ASHLEY AND CHANDLER BRIDGE FORMATIONS OF SOUTH CAROLINA, USA

**3:30** **K. Matsui**, **N. Pyenson**, **T. Tsuihiji**, **T. Ando** FOSSIL BALEEN WHALES (CETACEA, MYSTICETI) SHOW THAT BRAIN SHAPES ACHIEVED MODERN BEFORE BALEEN EVOLVED

**3:45** **J.H. Geisler**, **B.L. Beatty**, **R. Boessenecker** ORIGIN OF FILTER-FEEDING IN MYSTICETI (MAMMALIA: CETACEA) REVISITED

**4:00** **F.A. Perini**, **C.R. Moraes-Neto**, **P.G. Guedes**, **A.B. Carvalho**, **P.M. Toledo**, **J. Arroyo-Cabrales**, **L.D. Salles** INSIGHTS FROM MICROCT-SCAN OF THE EARLIEST FOSSIL BAT FROM BRAZIL – *MORMOPTERUS* (*NEOMOPS*) *FAUSTOI* (CHIROPTERA: MOLOSSIDAE), AN OLIGOCENE HOLOTYPE LOST IN THE FIRE OF THE MUSEU NACIONAL

**SATURDAY AFTERNOON, OCTOBER 21, 2023**
**TECHNICAL SESSION 21: SQUAMATES**
**MEETING ROOM JUNIOR BALLROOM D**
**MODERATORS: Meghan Forcellati and Helen Burch**

**1:45** **C. Sullivan**, **S.M. Hamilton**, **I. Paparella**, **P.R. Bell**, **N. Campione**, **F. Fanti**, **D.W. Larson**, **R.L. Sissons**, **M. Vavrek**, **M.J. Balsai** A SPECIMEN OF THE TAXONOMICALLY PRECARIOUS MONSTERSAURIAN LIZARD *PALAEOSANIWA CANADENSIS* FROM THE UPPER CRETACEOUS WAPITI FORMATION OF NORTHERN ALBERTA, CANADA

**2:00** **R.B. Benson**, **S. Walsh**, **V. Fernandez**, **E. Griffiths**, **J. Head**, **S. Evans** PARVIRAPTOR-LIKE SQUAMATE FROM THE MIDDLE JURASSIC OF SCOTLAND

**2:15** **J. Jacisin**, **A. Meza**, **T. Xu**, **A. Boville**, **M. Kemp** GREATER ANTILLEAN *ANOLIS* SKULLS AS A REPLICATE MODEL SYSTEM FOR STUDYING ADAPTIVE RADIATION AND EVOLUTIONARY CONVERGENCE

**2:30** **M.R. Forcellati**, **J.G. Napoli**, **A.R. Zietlow**, **D. Meyer**, **M. Hanson**, **A. Watanabe**, **C. Raxworthy** USING MACHINE LEARNING AND PHYLOGENETIC COMPARATIVE METHODS FOR PREDICTION OF ECOLOGY IN FOSSIL TAXA FROM INNER EAR BONY LABYRINTHS OF TOXICOFERANS (SQUAMATA, REPTILIA)

**2:45** **T. Jameson**, **J. Head** THE PAST, PRESENT, AND FUTURE OF DRAGONS: USING ECOMETRICS TO STUDY THE RESPONSES OF AUSTRALIAN *VARANUS* COMMUNITIES TO CLIMATE CHANGE

**3:00** **H. Petermann**, **D.W. Krause** LIFE-HISTORY PARAMETERS OF THE LATE CRETACEOUS SNAKE FAUNA OF MADAGASCAR

**3:15** **M. Riegler**, **L.W. Viñola-López**, **M.C. Vallejo-Pareja**, **J.R. Bourque**, **J.I. Bloch** EARLY MIOCENE SNAKES FROM FLORIDA AND A REASSESSMENT OF NORTH AMERICAN FOSSIL BOINES

**3:30** **I. Wilenzik**, **R. Pyron** ADAPTED BIOGEOGRAPHY METHOD UTILIZING BOTH PALEOGEOGRAPHIC AND FOSSIL DATA RECONSTRUCTS A EUROPEAN AND NORTHEASTERN ASIAN ORIGIN OF SQUAMATA

**3:45** **J. Head**, **M. Lawing**, **F. Kyalo Manthi**, **C. Mutinda**, **J. Müller**, **S. Cote**, **D.J. Peppe**, **K.P. McNulty** A NEOTROPICAL WET-FOREST SNAKE LINEAGE FROM THE EARLY MIOCENE OF EQUATORIAL AFRICA: BIOGEOGRAPHIC AND PALEOENVIRONMENTAL IMPLICATIONS

**4:00** **H.E. Burch**, **H. Eddins**, **M.R. Stocker**, **S.J. Nesbitt** A POTENTIALLY VENOMOUS LIZARD-LIKE REPTILE FROM THE LATE TRIASSIC (NORIAN) OF THE SOUTHWESTERN UNITED STATES

**SATURDAY AFTERNOON, OCTOBER 21, 2023**
**REGULAR POSTER SESSION 4**
**MEETING ROOM GRAND BALLROOM B**
**Authors must be present from 4:30 – 6:30 p.m. on Saturday, October 21**

**B246** **A. Steele**, **M. Fabbri**, **J. Wiemann**, **C.P. Bohus**, **N. Caroll**, **J. O'Connor** A NEW HIGHLY PRODUCTIVE MICROSITE FROM THE HELL CREEK FORMATION, MONTANA (USA)

**B247** **J.A. Moretti** NEW EVIDENCE OF LATE PLEISTOCENE VERTEBRATE DIVERSITY AND CHRONOLOGY FROM AN ONGOING INVESTIGATION OF INNER SPACE CAVERN ON THE EDWARDS PLATEAU OF TEXAS.

**B248** **J.E. Tharp**, **A.J. Kiss** STRUCTURAL AND EVOLUTIONARY ADAPTATIONS IN THE EYE LENS OF THE FREEZE-TOLERANT NORTH AMERICAN WOOD FROG (*RANA SYLVATICA)*

**B249** **S.P. Zbinden**, **M.C. Vallejo-Pareja**, **J.R. Bourque**, **D.C. Blackburn**, **J.I. Bloch** FOSSIL SALAMANDERS (AMPHIBIA, CAUDATA) FROM THE OLIGOCENE OF FLORIDA

**B250** **A. Lemierre** THE RETURN OF THE MUMMY: HOW EOCENE FROG MUMMIES FROM THE QUERCY PHOSPHORITES (SW, FRANCE) SHED LIGHT ON AN EUROPEAN PRESENCE OF AN AFRICAN CLADE

**B251** **R.K. Hunt-Foster**, **J.R. Foster**, **A. Hunt**, **J.I. Kirkland**, **K. Trujillo** DISTRIBUTION OF AMPHIBIANS IN THE MORRISON FORMATION (UPPER JURASSIC) OF THE ROCKY MOUNTAIN REGION, USA

**B252** **B.A. Clark**, **D.J. Varricchio** CT SCANNING AND BRIEF DESCRIPTION OF CRETACEOUS ANURAN MATERIAL FROM PTEROSAUR HILL, TWO MEDICINE FORMATION, MONTANA

**B253** **L.J. Rose**, **A.B. Heckert**, **J.P. Hancox** TAXONOMIC SIGNIFICANCE OF LUNGFISH (SARCOPTERYGII: DIPNOI) TOOTH PLATES IN THE LOWER TRIASSIC (OLENEKIAN) BURGERSDORP FORMATION OF DRIEFONTEIN, SOUTH AFRICA

**B254** **B. Fuller**, **A. Ramón**, **K. Claeson** MORPHOLOGY AND SYSTEMATICS OF LATE CRETACEOUS LUNGFISHES FROM MADAGASCAR

**B255** **C. Qu**, **Z. Pan**, **Y. Zhao**, **M. Zhu**, **J. Lu** A NEW POROLEPIFORM FISH FROM THE MIDDLE DEVONIAN, QUJING, YUNNAN, CHINA

**B256** **R. Ahmad**, **A. Khan**, **M. Waseem** ENAMEL HYPOPLASIA IN EXTINCT CERVIDS (DEER) AND THEIR ECOLOGICAL RESPONSES TOWARDS THE PLIOCENE HABITATS

**B257** **A.R. Evans**, **J. Edwards** THE GROWTH AND FORM OF HORNS IN MAMMALS AND DINOSAURS

**B258** **D.R. Prothero**, **B.L. Beatty** SYSTEMATICS OF THE LONG-NOSED FLORIDATRAGULINE CAMELS (ARTIODACTYLA: CAMELIDAE)

**B259** **M.I. Pardi**, **A. Woodruff**, **E. Mueller - Filipes**, **L. DeSantis** POPULATION-LEVEL DIETARY PROXIES DOCUMENT THE FORAGING BEHAVIOR OF FLAT-HEADED PECCARIES (*PLATYGONUS COMPRESSUS*) DURING SEASONAL DENNING IN BAT CAVE (OZARK PLATEAU, PULASKI CO., MO, USA)

**B260** **J.H. Miller**, **H. McDonald**, **M. Gaetano** BIOGEOGRAPHIC REORGANIZATION OF LATE PLEISTOCENE-HOLOCENE CARIBOU (*RANGIFER TARANDUS*)

**B261** **J. Gegner**, **S. Robson**, **J. Theodor** AN ANALYSIS OF THE INNER AND MIDDLE EAR OF *MERYCOIDODON*

**B262** **D.C. Kalthoff**, **G. Nesset Mattsson**, **T. Mörs**, **G.M. Semprebon** HARE-SIZED CAINOTHERIIDAE (MAMMALIA, ARTIODACTYLA) RELIED ON A FRUIT-DOMINATED BROWSING DIET

**B263** **K.I. Watmore**, **D.R. Prothero** DIETARY MODIFICATIONS OF THE TEETH IN THE EARLY MIOCENE STENOMYLINE CAMELS (CAMELIDAE: ARTIODACTYLA)

**B264** **E. Greiner**, **E. Orlikoff**, **W. El-Shaarawi**, **R. Sherwood** DENTAL MESOWEAR AND HYPSODONTY INDEX FROM TUGEN HILLS SUCCESSION BOVIDAE DEMONSTRATE RELIANCE ON MIXED-FEEDING AND INCORPORATION OF ABRASIVE DIETARY MATERIAL FROM LATE MIOCENE INTO PLIO-PLESITOCENE

**B265** **S.M. Santos**, **D.R. Prothero** ALLOMETRIC TRENDS IN LIMB REDUCTION OF THE PLEISTOCENE DWARF MOUNTAIN GOAT *OREAMNOS HARRINGTONI* (ARTIODACTYLA: BOVIDAE)

**B266** **A. Ayanarajan**, **D. Fraser**, **J. Mallon** HORN SIZE VARIATION WITH LATITUDE IN *BISON BISON*

**B267** **A.F. Schwartz**, **L. DeSantis**, **R.S. Scott** DENTAL MICROWEAR TEXTURE ANALYSIS OF SYMPATRIC SPECIES OF BASAL UNGULGATES (MAMMALIA, PHENACODONTIDAE) FROM EARLY PALEOGENE NORTH AMERICA

**B268** **S.M. Belabbes**, **L.N. Weaver**, **S.G. Chester**, **T. Lyson** FIRST OCCURRENCE OF THE EARLY PALEOCENE MAMMAL HEMITHLAEUS IN THE DENVER BASIN, COLORADO, WITH IMPLICATIONS FOR TOOTH REPLACEMENT IN ARCHAIC UNGULATES

**B269** **M. Riley**, **L.N. Weaver**, **T. Lyson** FIRST CRANIUM OF THE ENIGMATIC ARCHAIC UNGULATE MAMMAL *'CARCINODON'* IN THE DENVER BASIN, COLORADO, PROMPTS REEVALUATION OF THAT GENUS

**B270** **L.T. Holbrook**, **S.G. Chester** A CRANIUM OF *CHRIACUS BALDWINI* (MAMMALIA, ARCTOCYONIDAE) FROM THE PALEOCENE OF NEW MEXICO, USA, AND THE PHYLOGENETIC POSITION OF *CHRIACUS*

**B271** **B. Rodwell** THE FIRST KNOWN CERVICAL VERTEBRAE OF AN OMOMYOID PRIMATE, *SHOSHONIUS COOPERI*, AND THEIR BEARING ON TARSIER, ANTHROPOID, AND HAPLORHINE RELATIONSHIPS

**B272** **R.I. Collins**, **M.R. Borths**, **C. Borrelli** THE JUVENILE CRANIUM AND UPPER DECIDUOUS DENTITION OF *MEGALADAPIS MADAGASCARIENSIS* (LEMUROIDEA, STRESIRRHINE, PRIMATES)

**B273** **Y. Kimura**, **K. Yamada**, **I. Casanovas-Vilar**, **T.E. Cerling**, **A. Seki** MILK EFFECT ON TOOTH ENAMEL, BREATH, AND FASTING OF SMALL MAMMALS FROM FEEDING-CONTROLLED EXPERIMENTS FOR CARBON STABLE ISOTOPES

**B274** **S.G. Chester**, **J.W. Crowell**, **N. Mahadevan**, **B.T. Hovatter**, **G. Wilson Mantilla** QUANTIFYING PURGATORIID PLESIADAPIFORM DENTAL VARIATION AND DOCUMENTING SPECIES RICHNESS IN THE MIDDLE TULLOCK MEMBER, FORT UNION FORMATION, NORTHEASTERN MONTANA

**B275** **J.W. Crowell**, **K. Beard**, **S.G. Chester** NEW INSIGHTS INTO THE CRANIAL ANATOMY OF THE PALEOCENE PLESIADAPIFORM *PLESIOLESTES NACIMIENTI* (EUARCHONTA, PALAECHTHONIDAE)

**B276** **S. López-Torres**, **O. Bertrand**, **L. Fostowicz-Frelik**, **M. Lang**, **C.J. Law**, **G. San Martin Flores**, **M. Schillaci**, **M.T. Silcox** BRAIN SIZE ALLOMETRY AND ENCEPHALIZATION QUOTIENTS IN EUARCHONTOGLIRES

**B277** **C.C. Gilbert**, **R. Secord**, **A.E. Chew**, **S.G. Chester** NEW PRIMATE FOSSILS ACROSS THE EARLY EOCENE CLIMATIC OPTIMUM OF THE WIND RIVER BASIN, WYOMING

**B278** **S.E. Cobb**, **E. Locke**, **D. La**, **C. Kirchhoff**, **C. Terhune**, **S.B. Cooke** A MODEL FOR ESTIMATING PRECISE DIETARY COMPOSITION OF FOSSIL ANTHROPOIDS

**B279** **I.K. Lundeen** ADDITION, LOSS, AND EXPANSION OF OLFACTORY TURBINALS AMONG EXTINCT AND EXTANT PRIMATOMORPHANS

**B280** **K.L. Rust**, **K. Beard** ASSESSING MORPHOLOGICAL CHANGE IN THE UPPER DENTITION OF THE *TETONIUS* – *PSEUDOTETONIUS* (MAMMALIA, PRIMATES) LINEAGE FROM THE WILLWOOD FORMATION (EARLY EOCENE) IN THE BIGHORN BASIN OF WYOMING, USA

**B281** **I. Edwards**, **F. Socki**, **D.L. Fox** GEOMETRIC MORPHOMETRICS OF MANDIBLES: A 3D MODEL FOR THE EVOLUTION OF MANDIBULAR TRAITS OF THE GEOMYOIDEA CLADE (ORDER: RODENTIA).

**B282** **S. Skwarcan** WHY WOODRATS GIVE ME NIGHTMARES: A PHOTOGRAPHIC ATLAS OF DENTAL MORPHOLOGY

**B283** **M.R. Wyatt**, **N.S. Vitek**, **T.M. Smiley** MODERN SPATIAL DIVERSITY, DISPARITY, AND TURNOVER IN THE HETEROMYIDAE (RODENTIA)

**B284** **B. Neale**, **J.H. Miller**, **E. Wald**, **P.S. Druckenmiller** SMALL MAMMAL REMAINS FROM RAPTOR PELLETS PERSIST ON TUNDRA FOR AT LEAST DECADES (ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA)

**B285** **M.P. Ball**, **D.M. Poorboy**, **F. Socki**, **J.J. Calède** A DEEP TIME PERSPECTIVE ON BITE FORCE: A CASE STUDY IN GEOMORPH RODENTS

**B286** **M. Grau-Camats**, **I. Casanovas-Vilar**, **C.J. Crowe**, **J.X. Samuels** GLIDING BETWEEN CONTINENTS: THE RECORD OF THE FLYING SQUIRREL *MIOPETAURISTA* (SCIURIDAE, RODENTIA) IN NORTH AMERICA

**B287** **D. Flores**, **S. Hopkins** 2D MORPHOMETRIC ANALYSIS OF THE FIRST MOLAR OF MUROID RODENTS

**B288** **P.J. Lewis**, **K.M. Jenkins**, **D. Flores**, **W. Godwin**, **C.J. Bell** ADDITIONAL RECORD OF CAPYBARAS ON THE TEXAS GULF COAST

**B289** **A.D. Rincón** PHYLOGENY OF DINOMYIDAE RODENTS (RODENTIA, CAVIOMORPHA) FROM THE MIOCENE OF NORTHEN SOUTH AMERICA

**B290** **T.B. Bennett**, **D.B. Patterson**, **A. Mead** EFFECTS OF SNAKE DIGESTION ON SMALL MAMMAL SKELETONS

**B291** **E. Fulwood** PROBING THE DISTINCTIVE PREMOLARS OF PENTACODONTIDS (EUTHERIA: MAMMALIA)

**B292** **F.A. Perini**, **S. Lages**, **J.J. Flynn** REDESCRIPTION AND ANALYSIS OF THE CRANIAL ANATOMY AND PHYLOGENETIC AFFINITIES OF *PLEUROSTYLODON MODICUS*, AMEGHINO 1897 (MAMMALIA, NOTOUNGULATA)

**B293** **A. McGrath**, **D.A. Croft**, **J.D. Carrillo**, **M.G. Suárez Perez**, **A. Link Ospina** NEW LITOPTERN (PANAMERIUNGULATA; MAMMALIA) SPECIMENS FROM LA VENTA (MIOCENE; COLOMBIA) AND ECOMORPHOLOGY OF NEOGENE HERBIVORE COMMUNITIES ACROSS THE PANAMANIAN SEAWAY

**B294** **S. Lehr**, **H. Velazquez**, **F. Anaya**, **B.J. Shockey** MESOTHERIID NOTOUNGULATES FROM A NEW DESEADAN LOCALITY IN SW BOLIVIA

**B295** **P.D. Itie** THE CROSS DATING OF A PALEOGENE TYOPTHERIA TO DETERMINE THE AGE AND RANGE OF THE CACHAPOAL

**B296** **L. Veine-Tonizzo**, **J. Tissier**, **M. Bukhsianidze**, **D. Vasilyan**, **D. Becker** CRANIAL MORPHOLOGY AND PHYLOGENETIC RELATIONSHIPS OF AMYNODONTIDAE SCOTT & OSBORN, 1883 (PERISSODACTYLA, RHINOCEROTOIDEA)

**B297** **O.A. Goodchild**, **S. Rosen**, **J. Tissier**, **J. Meng** MORPHOLOGY OF THE PETROSAL AND BONY LABYRINTH OF EXTINCT EQUIDAE (PERISSODACTYLA) AND PRELIMINARY PHYLOGENETIC ANALYSIS

**B298** **S. Killingsworth**, **B.J. MacFadden** SPECIES OCCURRENCES OF LATE MIOCENE HORSES (EQUIDAE) FROM FLORIDA: SAMPLING, ECOLOGY, OR BOTH?

**B299** **A.D. Weber**, **D.A. Croft** XENARTHRAN MORPHOLOGICAL DISPARITY AND IMPLICATIONS FOR CINGULATE TAXONOMY

**B300** **R.J. Gay**, **K. Bingham**, **M. Berry**, **P. Walker**, **J. Lopez**, **T. Deemyad** ROBODINO: ADVANCES IN ROBOTICS AS APPLIED TO A PALEONTOLOGY INTERACTIVE DISPLAY

**B301** **S.K. Drumheller**, **C.A. Boyd**, **M. Mayhall**, **E. Stalker**, **M. Householder** THE CURSE OF THE MUMMY’S HAND: DIGIT CONSOLIDATION WITH MULTI-DIGIT NAIL PARTICIPATION REVEAL A NOVEL FORM OF SYNDACTYLY IN THE HAND OF A MUMMIFIED *EDMONTOSAURUS*

**B302** **J. Scannella**, **K. Purens**, **J.R. Horner** A MORPHOMETRIC ASSESSMENT OF CRANIAL ONTOGENETIC AND EVOLUTIONARY TRENDS IN *TRICERATOPS* FROM THE HELL CREEK FORMATION, MONTANA

**B303** **M.A. Chiappone**, **M. Guala**, **R. Rogers**, **P. Makovicky** CHARACTERIZING TRANSPORT IN HADROSAUROID DINOSAURS: AN ACTUALISTIC EXPERIMENTAL APPROACH TO FLUVIAL TAPHONOMY

**B304** **A. Evangelista**, **N. Campione**, **J. Scannella** A GIGANTIC HADROSAURID SPECIMEN FROM THE UPPERMOST CRETACEOUS HELL CREEK FORMATION OF MONTANA WITH IMPLICATIONS FOR DINOSAUR DIVERSITY

**B305** **H.M. Avrahami**, **C.M. Hauser**, **L.E. Zanno** NEW ADDITIONS TO THE EARLY DIVERGING ORNITHISCHIAN *ZEPHYROSAURS SHAFFI* FROM THE CRETACEOUS CLOVERLY FORMATION OF NORTH AMERICA

**B306** **J. Wilson**, **M.J. Ryan**, **G.M. Erickson**, **P.S. Druckenmiller** NEW CRANIAL MATERIAL OF THE CENTROSAURINE CERATOPSID DINOSAUR *PACHYRHINOSAURUS PEROTORUM* FROM THE CAMPANIAN PRINCE CREEK FORMATION, ALASKA

**B307** **K. Nguyen**, **P.J. Currie** CONSPICUOUS PARIETAL ASYMMETRY IN TWO CENTROSAURINE TAXA FROM ALBERTA, CANADA

**B308** **D.S. Large** FIRST OCCURRENCE OF *GARGOYLEOSAURUS* (DINOSAURIA: ANKYLOSAURIA) IN UTAH; THE IMPORTANCE OF OSTEODERMS FOR THE PURPOSE OF TAXONOMY

**B309** **K. Obuszewski**, **N. Smith** AN OSTEOHISTOLOGICAL ANALYSIS OF *TRICERATOPS* POSTORBITAL HORNS

**B310** **K.C. Rayburn**, **J. King**, **F. Varriale**, **M. Son**, **G. Phillips** NEW INSTANCES OF CERATOPSIAN (DINOSAURIA: CERATOPSIA) TEETH FROM APPALACHIA IMPLY MULTIPHASE LATE CRETACEOUS MIGRATIONS

**B311** **D.D. Johnson**, **L. Turner**, **G. Austin**, **Z. Hannebaum**, **D.J. Varricchio** WALKING ON EGGSHELLS - BONE MODIFICATION AND ‘DINOTURBATION’ AT EGG MOUNTAIN, MT USA

**B312** **B. Conway**, **J.E. Peterson** DISTRIBUTION, FREQUENCY, AND HISTOLOGY OF PATHOLOGICAL ELEMENTS IN CENTROSAURINAE

**B313** **J.I. Kirkland**, **D.D. DeBlieux**, **E. Warner-Cowgill**, **J.R. Lively** NEW POLACANTHINE ANKYLOSAURS FROM THE BASAL CRETACEOUS (BERRIASIAN), LOWER YELLOW CAT MEMBER (YCM) OF THE CEDAR MOUNTAIN FORMATION (CMF), NORTHERN PARADOX BASIN, GRAND COUNTY, UTAH

**B314** **W. Ma** MASTICATORY BIOMECHANICS IN THE ANKYLOSAURIAN DINOSAUR *PANOPLOSAURUS MIRUS*

**B315** **E.G. Cross**, **V. Arbour** AN ANKYLOSAUR FEMUR FROM THE DUNVEGAN FORMATION OF NORTHEASTERN BRITISH COLUMBIA

**B316** **I.S. Hutchinson**, **P. Ullmann**, **J.S. Keller**, **J.R. Moore** TAPHONOMIC AND RARE EARTH ELEMENT ANALYSIS OF HADROSAUR FEMUR FROM PALEOCENE ROCKS IN THE SAN JUAN BASIN, NEW MEXICO

**B317** **A. Danison**, **C. Heck**, **H. Flora**, **H. N. Woodward** DINO JOHN DOE: UTILIZING OSTEOHISTOLOGY AND MORPHOMETRICS IN SPECIES IDENTIFICATION OF AN ISOLATED ORNITHISCHIAN TIBIA FROM THE LATE CRETACEOUS

**B318** **B. Perkins**, **J. Reizner** THE METABOLIC RATE OF *EINIOSAURUS PROCURVICORNIS* DETERMINED WITH PHYLOGENETIC EIGENVECTOR MAPS

**B319** **L.T. Dickson**, **V. Arbour** TRIDACTYL FOOTPRINTS REFERABLE TO *ANOMOEPUS* SP. FROM THE LATE JURASSIC-EARLY CRETACEOUS MIST MOUNTAIN FORMATION OF SOUTHEASTERN BRITISH COLUMBIA

**B320** **V.J. Radermacher**, **P. Makovicky**, **C.A. Suarez**, **M. Suarez**, **M. Allen** A NODOSAUR TRACK (*TETRAPODOSAURUS*) FROM THE EARLY CRETACEOUS SYKES MOUNTAIN FORMATION OF WYOMING

**B321** **S.L. Booth**, **Z. Boles** DESCRIPTION OF THE SMALLEST KNOWN SPECIMEN OF THE PLEURODIRAN SEA TURTLE *TAPHROSPHYS SULCATUS* FROM THE EDELMAN FOSSIL PARK, MANTUA TOWNSHIP, NEW JERSEY, AND IMPLICATIONS OF ONTOGENY ON ITS ECOLOGY

**B322** **J. Prall**, **G. Panascí**, **Z. Hannebaum**, **D.A. Orme**, **D.J. Varricchio** NEW *BASILEMYS* TURTLE FROM THE UPPER CRETACEOUS FRONTIER FORMATION NEAR LIMA, MT

**B323** **D.W. Larson**, **V. Arbour**, **S. McLachlan** FIRST RECORD OF TURTLE EGGS FROM THE UPPER CRETACEOUS NANAIMO GROUP OF VANCOUVER ISLAND, BRITISH COLUMBIA, CANADA

## VIRTUAL POSTERS

**B324** **R. Germano**, **N. Ferregueti**, **Y.L. Leite** TRIVIA GAME AS A TOOL FOR TEACHING EVOLUTION, PALEONTOLOGY AND THE HISTORY OF LIFE TO UNDERGRADUATE STUDENTS

**B325** **P.J. Wilson** PROCEDURE FOR THE DOCUMENTATION OF PALEONTOLOGICAL LOCALITIES AT BADLANDS NATIONAL PARK, INTERIOR, SOUTH DAKOTA

**B326** **S. Hilburn**, **D. Capps**, **P. Brease**, **V. Santucci** A NEW PALEONTOLOGICAL RESOURCES MANAGEMENT PLAN FOR DENALI NATIONAL PARK AND PRESERVE

**B327** **A. Prieto-Marquez**, **J. Wagner** A NEW EARLY-DIVERGING HADROSAURID (DINOSAURIA: ORNITHOPODA) FROM THE UPPER CAMPANIAN AGUJA FORMATION OF TRANS-PECOS TEXAS, USA

**B328** **G.M. Semprebon** MULTI-PROXY DIETARY RECONSTRUCTION OF DERIVED EQUINAE FROM THE MIOCENE THROGH THE PLIO-PLEISTOCENE OF NORTH AMERICA

**B329** **E. Einarsson**, **J.A. Gren**, **S. Johansson** X-RAY MICROTOMOGRAPHY AND 3D VISUALIZATION OF A PLESIOSAUR PROPODIAL (REPTILIA: SAUROPTERYGIA) FROM THE LATE CRETACEOUS OF SOUTHERN SWEDEN PROVIDES INSIGHTS IN BONE HISTOLOGY, BONE MICROSTRUCTURES, AND BONE GROWTH.

**B330** **M. Montellano Ballesteros**, **M. Vazquez**, **C. Barrón-Ortiz**, **J.E. Ramos-Heredia**, **J.A. Ramos-Heredia** NEW MATERIAL OF A GROUND SLOTH *NOTHROTHERIOPS* SP. (MAMMALIA: XENARTHRA) FROM THE EL CEDAZO LOCAL FAUNA, AGUASCALIENTES, MÉXICO

**B331** **J. Botha**, **K. Chapelle**, **P. Barrett**, **R. Benson**, **T. Seerane**, **F. Tolchard**, **J. Choiniere** RAPID GROWTH IN A NEW LATE TRIASSIC POPOSAUROID FROM THE SOUTH AFRICAN KAROO BASIN

**B332** **A. Moopen**, **K. Chapelle**, **R. Benson**, **P. Barrett**, **J. Botha**, **J. Choiniere** SOUTH AFRICA'S EARLIEST GIANT: THE SYSTEMATICS AND PALEOBIOLOGY OF A NEW SAUROPODOMORPH DINOSAUR

**B333** **T. Tsubamoto**, **Y. Kunimatsu**, **M. Nakatsukasa** THE CAINOCHOERINAE (MAMMALIA, ARTIODACTYLA, SUIDAE) FROM THE BASAL UPPER MIOCENE NAKALI FORMATION, KENYA

**B334** **R. Moya-Costa**, **O. Bertrand**, **À. Luján**, **I. Casanovas-Vilar**, **M. Furió** HEDGEHOG PALEONEUROLOGY: VIRTUAL BRAIN ENDOCAST OF *POSTPALERINACEUS VIRETI* (EULIPOTYPHLA, MAMMALIA) AND COMPARISON WITH EXTANT ERINACEIDAE

**B335** **A.K. Valcourt**, **V. Arbour** CANADA'S MOST COMPLETE *MERYCOIDODON* FOSSIL

**B336** **R.R. Rayner**, **R. Butler**, **C.F. Kammerer**, **J. Choiniere** AN EXAMINATION OF GOMPHODONT MATERIAL FROM THE *CYNOGNATHUS* ASSEMBLAGE ZONE OF THE BURGERSDORP FORMATION OF SOUTH AFRICA AND THE IDENTIFICATION OF THREE NEW SPECIES, WITH POTENTIAL IMPLICATIONS ON STRATIGRAPHICAL CORRELATIONS

**B337** **T. Tanaka**, **K. Chiba**, **T. Ikeda**, **M.J. Ryan**, **K. Kubota** A BASAL NEOCERATOPSIA (ORNITHISCHIA: CERATOPSIA) FROM THE LOWER CRETACEOUS OHYAMASHIMO FORMATION (ALBIAN), SOUTHWESTERN JAPAN

**B338** **M. Boisville**, **N. Chatar**, **N. Kohno** NEW SPECIMENS OF PLIO-PLEISTOCENE ODOBENINES FROM THE NORTH SEA GIVE NEW INSIGHT ON THE PAST DIVERSITY OF THE GENUS *ONTOCETUS*

**B339** **V.A. Pérez Crespo**, **G. Pérez-Roldan**, **E. Cienfuegos-Alvarado**, **F. Otero** FEEDINGS HABITS OF PLEISTOCENE MAMMALS FROM RANCHO CARAMBANCHEL, SAN LUIS POTOSI, MÉXICO: BIOGEOCHEMICAL APPROACH

**B340** **A.A. Rytel**, **D. Surmik**, **T. Szczygielski**, **T. Scheyer** UNIQUE INTERNAL ANATOMY OF CERVICAL VERTEBRAE DISCOVERED IN TRIASSIC ARCHOSAUROMORPHS FROM CENTRAL EUROPE

**B341** **D.D. Badea**, **M. BRANZILA**, **B. RATOI** THE FIRST APPARENCE OF A SMALL-SIZED BEAVER (CASTORIDAE, MAMMALIA) FROM THE LATE MIOCENE (EARLY TUROLIAN) OF MOLDAVIAN PLATFORM, EASTERN ROMANIA

**B342** **B. Curtice**, **R. Wilhite** DESCRIPTION OF NEW BRACHIOSAURID MATERIAL FROM THE LATE JURASSIC MORRISON FORMATION DRY MESA DINOSAUR QUARRY, REDESCRIPTION OF POTTER CREEK BRACHIOSAURID REMAINS, AND REFERRAL OF NEW LOCALITIES TO *BRACHIOSAURUS*

**B343** **T. Ikeda**, **H. Ota**, **T. Tanaka** A NEW FOSSIL LIZARD WITH TRICUSPID TEETH FROM THE LOWER CRETACEOUS OHYAMASHIMO FORMATION OF THE SASAYAMA GROUP, HYOGO, JAPAN

**B344** **M. Dantas**, **A. Cherkinsky** INTERRELATION OF RADIOCARBON AGES BONE FRACTIONS IN THE BRAZILIAN INTERTROPICAL REGION

**B345** **L. Roriz**, **M. Dantas** COULD *SMILODON* CLIMB TREES?

**B346** **L.A. Fox-Pendergrast**, **A.P. Cossette** NEW EVIDENCE SUGGESTS THAT *DEINOSUCHUS RIOGRANDENSIS* SHOULD FORM THE TYPE SPECIES OF *DEINOSUCHUS*

**B347** **A.P. Cossette** *CHRYSOCHAMPSA MYLNARSKII* FROM THE EARLY EOCENE GOLDEN VALLEY FORMATION OF NORTH DAKOTA, U.S.A. REVEALS A LATE-LIVED MEMBER OF A CRETACEOUS CLADE

**B348** **A. Sullivan**, **K. Poole** CRANIAL ANATOMY AND PHYLOGENETIC ANALYSIS OF BASAL IGUANODONTIAN *HIPPODRACO SCUTODENS* WITH HIGH RESOLUTION COMPUTED TOMOGRAPHY

**B349** **R.V. Hill**, **R. Sarr**, **X.A. Jenkins**, **L. Tapanila**, **M.A. O'Leary** AN ASSEMBLAGE OF VERTEBRATE MACROFOSSILS AND MICROFOSSILS FROM THE LATE CRETACEOUS OF SENEGAL

**B350** **S.Z. Gibson**, **S.M. Ott** NEWLY DISCOVERED FISH FAUNA FROM THE UPPER TRIASSIC DOCKUM GROUP OF WESTERN TEXAS

**B351** **E. Snively**, **A. Pennings**, **E.D. Johnson-Ransom**, **A. Claxton** "NUTCRACKER" BITE MECHANICS IN *TYRANNOSAURUS REX* TESTED WITH MULTI-PERMUTATION STRUCTURAL ANALYSES

**B352** **T. Aureliano**, **A.M. Ghilardi** THE EVOLUTION OF THE AIR SAC SYSTEM IN NON-AVIAN THEROPOD DINOSAURS: EVIDENCE FROM THE UPPER CRETACEOUS OF MADAGASCAR

**B353** **S. Lautenschlager** ORBIT SIZE AND ESTIMATED EYE SIZE AND THEIR IMPLICATIONS FOR VISUAL CAPABILITIES IN DINOSAURS AND OTHER ARCHOSAURS

**B354** **M. Ammar**, **A. Iqbal**, **A. Khan**, **M. Waseem**, **A. Naseer** SEXUAL DIMORPHISM REVEALED THROUGH CRANIOMETRICAL ANALYSIS IN *MACACA MULATTA* FROM NORTHERN PAKISTAN

**B355** **S.P. Zack** A NEW SPECIES OF *SIMIDECTES* FROM THE EARLY UINTAN OF CALIFORNIA CLARIFIES THE AFFINITIES OF THE GENUS

**B356** **L. Chapa**, **P. Chapa**, **A. Nourie**, **E. Wolff**, **J.R. Moore** UNCOVERING DINOSAUR DEATH POSE: UTILIZING QUANTITATIVE AND QUALITATIVE METHODS TO ANALYZE THE DRIVERS OF OPISTOTHONIC DEATH POSTURE IN DINOSAURS

**B357** **J.R. Milligan**, **E. Bamforth**, **M.G. Mangano**, **L.A. Buatois** RHIZOETCHING TRACE FOSSILS ON *TRICERATOPS* BONES FROM THE LATEST CRETACEOUS FRENCHMAN FORMATION, SASKATCHEWAN, CANADA; INSIGHT INTO RECONSTRUCTING TAPHONOMIC PATHWAYS OF VERTEBRATES IN PALEOSOLS

**B358** **B. Holgado** A NEW PHYLOGENETIC PROPOSAL OF THE PTERANODONTOIDEA WITH SPECIAL FOCUS ON THE PTERANODOTIA AND A MORPHOMETRIC ANALYSIS OF THE NYCTOSAURIDAE

**B359** **M.C. Carpenter** BADLANDS NATIONAL PARK: INTEGRATING SCIENTIFIC EDUCATION, OUTREACH, AND CITIZEN SCIENCE WITH AN OPEN CONCEPT FOSSIL PREPARATION LAB

**B360** **P. Houde** FIRST POTENTIAL RECORD OF “TERROR BIRD” FROM THE PALEOGENE OF NORTH AMERICA (AVES: CARIAMIFORMES: PHORUSRHACIDAE)

**B361** **S.E. Jasinski** A FOSSIL BOX TURTLE FROM NEAR THE MIOCENE-PLIOCENE BOUNDARY AND ITS POTENTIAL ROLE IN THE SEMI-AQUATIC TO TERRESTRIAL LIFESTYLE TRANSITION DURING THE EVOLUTION OF *TERRAPENE* (EMYDIDAE)

Technical Session 18: Synapsids (Saturday, October 21, 2023, 8:00 AM)

**SQUISHING THE SQUISHED: THE EFFECTS OF TAPHONOMIC DEFORMATION AND WEATHERING ON THE INTERPRETATION OF TAXONOMIC VARIATION IN SPECIES OF *LYSTROSAURUS* (ANOMODONTIA) IN THE KAROO BASIN, SOUTH AFRICA**

Abbott, Caroline P.

Committee on Evolutionary Biology, The University of Chicago, Chicago, Illinois, United States

The Permo-Triassic Mass Extinction (PTME; 251.9 Ma) was the worst biodiversity crisis in Earth history, with high levels of extinction, altered community structures, and lasting life history and physiological shifts for individual taxa. The terrestrial PTME is well-recorded in the Karoo Basin, South Africa, where it has been well-studied for over a century. Abundant taxa, such as the dicynodont *Lystrosaurus*, are useful for biostratigraphy and understanding the PTME because of their large sample size and broad geographic distribution. Furthermore, changes in *Lystrosaurus'* body size, histology, and ontogeny during the PTME are a compelling system for understanding macroevolutionary life history shifts in response to climate change.

Historically, *Lystrosaurus* taxonomy included 27 morphospecies, many of which were based on different deformation styles of similar skulls. Currently, four species are recognized in the Karoo: *L. maccaigi, L. curvatus, L. declivis, and L. murrayi*. Boundaries between these species are more reliable, but still suffer from taphonomic biases, including deformation and weathering. Given its central role in studies of the PTME, improved species diagnoses for *Lystrosaurus* are needed that account for how taphonomy and deformation affect specimen identification.

I assessed 45 discrete characters in over 120 *Lystrosaurus* crania across a range of sizes, inferred ontogenetic stages, and prior species assignments. *Lystrosaurus* crania exhibit a wide range of brittle and plastic deformation modes across all species and ontogenetic/size stages. The two Permian species, *L. curvatus* and *L. maccaigi*, are diagnosable regardless of ontogeny, size, and deformation, and almost certainly represent true morphospecies. The two Triassic species are more problematic due to their similarity and the effects of taphonomy. Although qualitatively it is clear that there is more than one Triassic species of *Lystrosaurus*, the classic diagnostic features between *L. murrayi* and *L. declivis* are highly subject to alteration based on deformation, historic preparation, and other taphonomic processes. Triassic skulls are more likely to be called "*L. murrayi*" if dorsoventrally compressed and more likely to be called "*L. declivis*" if mediolaterally and/or anteroposteriorally compressed. These results highlight the need for additional quantification of ontogenetic changes in *Lystrosaurus*, and consideration of taphonomy in taxonomic and phylogenetic work on the genus.

**Funding Sources** Donald Steiner Award and Hinds Fund Award, Biological Sciences Division, The University of Chicago

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**A UNIQUE PATHOLOGY IN AN APATOSAURINE (SAUROPODA, DIPLODOCIDAE) FEMUR FROM THE MORRISON FORMATION (UPPER JURASSIC) OF WYOMING, USA**

Acosta, Matilde R.[1], Koenig, Elaude[2], Blomberg, Owen H.[2], Kufner, Aaron M.[3], Haridy, Yara[4], Lovelace, David M.[5]

[1]Life Science Communication, University of Wisconsin-Madison, Madison, Wisconsin, United States, [2]Department of Integrated Biology, University of Wisconsin-Madison, Madison, Wisconsin, United States, [3]Department of Geoscience, University of Wisconsin- Madison, Madison, Wisconsin, United States, [4]Organismal Biology and Anatomy, University of Chicago, Chicago, Illinois, United States, [5]University of Wisconsin Geology Museum, Madison, Wisconsin, United States

Pathologies of sauropod limbs are understudied and not well understood despite the implications they may have for the physiology, disease, as well as mode and rate of healing for animals living at the limits of structural possibility for vertebrates. During the preparation of a femur (UWGM 7213) from the Westphal Quarry in Wyoming, a scalloped excavation with a raised margin was observed encompassing a small portion of the lateral condyle and much of the anterolateral epicondylar surface.

This feature is reminiscent of erosive pathology with secondary bone reaction and appears to be a novel and undocumented pathology in a sauropod dinosaur knee joint. The Westphal Quarry is a bone bed from the upper Morrison Formation in the east-central Bighorn Basin, WY, recognized to be a multitaxic vertebrate assemblage dominated by apatosaurine sauropod remains. Although the majority of elements are disarticulated, some show association. For example, UWGM 7214 is a partially articulated pelvis consisting of left and right ischia, a left pubis, and has a strong association with UWGM 7213. We compared UWGM 7213 with other diplodocid femora and with the modern and paleopathology literature to better understand mechanisms of the potential injury and subsequent bone modification. Preliminary comparisons suggest the pathology is consistent with an erosive reaction due to soft tissue inflammation resulting in pressure that may have incited subperiosteal osteoclastic activity. Lesions such as the one in this specimen can be induced by internal diseases such osteoarthritis, degenerative subchondral bone cysts, or even cancer. However, similar lesions can result from traumatic injuries that cause secondary infection or improperly heal over time. Therefore, additional analysis such as computed tomography and histological sections are critical to the differential diagnosis of this Late Jurassic knee pathology. Both the likely impact this injury had on mobility and that the injury appears to have been healed suggest potential herd behaviors towards an injured member. Moreover, this paleopathological study will help improve our understanding of the healing physiology of sauropods.

**Funding Sources** Friends of the Geology Museum; Sherry Lesar Fund for Geological Wonder

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Technical Session 16: Theropods - I (Saturday, October 21, 2023, 8:00 AM)

**TYRANNOSAURID HINDLIMB FROM THE JAVELINA FORMATION (LATE CRETACEOUS, MAASTRICHTIAN) OF BIG BEND NATIONAL PARK, TEXAS**

Adams, Thomas L.[1], Tykoski, Ronald S.[2], Drumheller, Stephanie K.[3], N. Woodward, Holly[4]

[1]Curatorial, Witte Museum, San Antonio, Texas, United States, [2]Perot Museum of Nature and Science, Dallas, Texas, United States, [3]University of Tennessee, Knoxville, Tennessee, United States, [4]Oklahoma State University Center for Health Sciences, Tulsa, Oklahoma, United States

The Texas record of Maastrichtian tyrannosaurid dinosaurs is largely based upon isolated teeth and the rare skeletal elements, primarily from Big Bend National Park in southwest Texas. The most well-known Texas tyrannosaur fossil is an isolated left maxilla with incomplete dentition, now regarded as belonging to a subadult *Tyrannosaurus rex*. In 2002 and 2009, a partial tyrannosaur right hind limb (BIBE 45850) was excavated from deposits of the upper Javelina Formation (Maastrichtian) in the northeast section of Big Bend National Park. The specimen includes a nearly complete tibia, portions of the fibula, and the second, third, and fourth metatarsals, representing the most complete tyrannosaurid currently known from Texas. BIBE 45850 is confidently assigned to Tyrannosauridae based on the overall morphology of the limb elements; including the arctometatarsalian metatarsus. At present, lower-level identification is uncertain due to a lack of more complete, diagnostic elements. The length of the tibia (860 mm) is only 75% that of the large adult *T. rex* FMNH PR2081 (1143 mm), suggesting it either came from a subadult individual or potentially a new, small-bodied tyrannosaurid species.

In addition, the distal end of metatarsal III preserves a series of eight deep bite marks, along the anterior and posterior condylar surfaces. They are subparallel in orientation and spacing, suggesting either a single or two sequential serial biting events. Their position, on and around the articular surface, provides a potential explanation for why the remainder of the right pes is missing. The spacing and the broadly V-shaped cross section of each furrow and puncture suggest that a large-bodied theropod, likely a conspecific given the taxa known from the formation, is the most likely trace maker. The poor surface quality preservation and the lack of more diagnostic features of the marks means that other large predators with relatively conical, homodont dentition, such as crocodyliforms, cannot fully be excluded. Because late Maastrichtian tyrannosaurids from the southernmost regions of North America are so rare, the discovery of a relatively complete tyrannosaurid hind limb provides an opportunity for reassessing the occurrence of *Tyrannosaurus* in Texas.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**ENAMEL HYPOPLASIA IN EXTINCT CERVIDS (DEER) AND THEIR ECOLOGICAL**

## RESPONSES TOWARDS THE PLIOCENE HABITATS

Ahmad, Rana Manzoor[1], Khan, Abdul Majid[2], Waseem, Muhammad Tahir[3]

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This is the first ever report on the occurrence of enamel hypoplasia in Pliocene cervids (deer). Enamel hypoplasia is a mammalian dental defect characterized by suppressed function of enamel forming cells called ameloblasts. Enamel hypoplasia is a strong and reliable proxy to trace out the ecological responses of living as well as extinct mammals towards changing climatic conditions. In this study, we have analyzed the linear enamel hypoplasia in the dental remains of the Pliocene cervids from the Early-Late Pliocene (ca. 5.4-2.5 Ma) Siwalik outcrops of Pakistan to assess the ecological stability of these mammals in changing climatic conditions. The extinct cervid taxa included in this study are *Axis punjabiensis*, *Cervus rewati*, *Cervus sivalensis, Cervus triplidens* and *Rucervus simplicidens*. According to our results there was a lower occurrence of enamel hypoplasia (18%) in the cervid fossils from the Early Pliocene outcrops as compared to the Late Pliocene cervid remains (48%) which is statistically significant ($p<0.05$). Grasslands were more dominant in the Siwaliks during the Late Pliocene as compared to the Early Pliocene epoch. During the Late Pliocene, the climate was marked by more pronounced seasonality in which precipitation shifted to few monsoonal months in the summers while riverine systems shrank. The current enamel hypoplasia results indicate that this increased intensity of climatic and vegetational changes during the Early Pliocene to the Late Pliocene posed certain stress to the Siwalik cervids that might be a reason to their extinction during the Pleistocene from the Siwaliks of Pakistan.

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

## NEW DENTAL REMAINS OF A LARGE TERATODONTINE (HYAINAILOURIDAE, MAMMALIA) FROM THE LATE EOCENE OF THE FAYUM DEPRESSION, EGYPT

Al-Ashqar, Shorouq F.[1], Borths, Matthew[2], Sieffert, Erik[3], El-Sayed, Sanaa[1], Sallam, Hesham M.[1]

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Through a well-sampled succession, the Fayum Depression, Egypt, offers detailed insights into the evolution of terrestrial mammals from the late Eocene through the early Oligocene. The fossil site Birket Qarun Locality 2 (BQ-2) is the oldest locality in the Fayum Depression (early late Eocene, ~37 Ma) that preserves a terrestrial fauna. BQ-2 hosts a diverse array of mammalian lineages, including Hyaenodonta, which were the most diverse carnivorous mammals on the Afro-Arabian continent during the Paleogene. Locality 41 (L-41) is the next-most fossiliferous terrestrial site in the Fayum sequence (~34 Ma). Previous studies have described a diversity of hyaenodonts from L-41, including mesocarnivorous teratodontine genera (*Masrasector* and *Brychotherium*). However, the carnivore fauna that gave rise to this L-41 diversity remains poorly understood. Here, we introduce a new, jackal-sized teratodontine taxon from BQ-2. The new taxon is known from dental remains, including the first and second upper and lower molars. The dental materials reveal that the paracone and metacone are similar in height and are both compressed buccolingually, though like other teratodontines, the metacone is more compressed and mesiodistally elongated. The protocone is triangular and defines a broad trigon basin that has a distinct paraconule and metaconule. The paraconule is slightly larger than the metaconule. On the lower molars, the metaconid is present, though lower than the carnassial-bearing paraconid and protoconid. The talonid basin is relatively large, forming nearly half of the mesiodistal length of m2, and it retains the primary talonid cusps. These characters are consistent with a mesocarnivorous diet for the new teratodontine. This new taxon is similar in size and dental morphology to *Brychotherium ephalmos* from L-41. The addition of this taxon to the hyaenodont diversity of BQ-2 suggests there was continuity through the late Eocene Fayum carnivore fauna. Documenting the full diversity of hyaenodonts through this interval is especially important for interpreting faunal changes across the Eocene-Oligocene Boundary. It is also important for understanding early teratodontine morphology and the evolution of hypercarnivory, as this clade of Eocene and Oligocene mesocarnivores gave rise to several lineages of hypercarnivores in the Miocene.

**Funding Sources** Mansoura University, American University in Cairo, Science and Technology Development Fund (STDF)

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Colbert Poster Prize Session

**AN EARLY ORIGIN OF GIGANTISM IN ANACONDAS (SERPENTES: *EUNECTES*) REVEALED BY THE FOSSIL RECORD**

Alfonso Rojas, Andres F.[1], Carrillo-Briceño, Jorge D.[2], Sánchez, Rodolfo[3], Sanchez-Villagra, Marcelo R.[2], Head, Jason J.[1]

[1]Department of Zoology, University of Cambridge, Cambridge, United Kingdom, [2]Department of Paleontology, University of Zurich, Zurich, Switzerland, [3]Museo Paleontológico de Urumaco, Urumaco, Falcon, Venezuela, Bolivarian Republic of

Extant snakes demonstrate a wide range of body sizes, from 10 cm to upwards of 8 m, with the largest sizes occurring in pythonids and the green anaconda *Eunectes murinus*. The timing and ecological contexts for the origin of gigantism in these taxa is poorly understood due, primarily, to an understudied fossil record for tropical snakes, despite well-constrained histories of environmental and faunal changes at equatorial latitudes over the last 66 million years. Field research in the Urumaco and Soccoro formations of Venezuela have produced a fossil record of *Eunectes* consisting of 18 specimens from 13 different localities spanning a temporal interval from Middle to Late Miocene (~15-7 Mya.), which provides a rich dataset to constrain body size histories for anacondas.

We identified the fossil specimens based on vertebral morphologies, including the presence of a median tubercle at the base of the zygosphene and the curved shape of the interzygapophysial ridges on dorsal view. We reconstructed body size using linear regression models of vertebral measurements from precloacal (mid-trunk) vertebrae against Total Body Length (TBL). Our results demonstrate maximum TBLs of 5.0-5.5 m as early as 15 Mya. Applying this to other anaconda records indicates that large body size is present at the earliest known occurrences of the genus.
We demonstrate giantism in *Eunectes* during the Miocene, but below recorded size maxima in extant populations, despite occurring in the globally warm climates in the Neogene Pebas wetland system, which features examples of extreme giantism in other reptiles such the podocnemidid turtle *Stupendemys*, and the crocodilians *Purusaurus* and *Gryposuchus*. The absence of similar extraordinary size extremes in Miocene *Eunectes* suggests that body size maxima in anacondas might be constrained by life history factors such as prey availability, growth rates and reproductive mode.

**Funding Sources** Gates Cambridge Trust, Natural Environment Research Council grants NE/W007576/1 and NE/ S000739/1 and Instituto del Patrimonio Cultural in Caracas (certificado 071/15)

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Technical Session 7: Birds (Thursday, October 19, 2023, 8:00 AM)

**QUANTIFYING THE CONVERGENCE OF AVIAN CRANIAL OUTGROWTHS: A PRELIMINARY STUDY OF INTERACTIONS BETWEEN NATURAL AND SEXUAL SELECTION**

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Exaggerated osteological outgrowths have evolved independently in many extant and extinct vertebrate lineages. Posited functions for these structures range from physiological to reproductive, giving rise to hypotheses that these outgrowths arose through sexual selection, narrow-sense natural selection, or both. Numerous extant bird species, such as hornbills and cassowaries, possess cranial outgrowths previously shown to serve survival functions, yet these structures are also subject to sexual selection. Despite apparent functional similarities, cranial outgrowths are morphologically diverse, and therefore the amount of evolutionary convergence among these structures is currently unclear. We applied phylogenetic comparative approaches to 3D surface scans of the bill and frontal region of skulls from 82 bird species to measure: 1) quantitative convergence of the shape of the enlargements among sampled taxa; and 2) strength of the correlations between region shape and ecological traits such as range size, latitude, and mean annual temperature. Our results indicate that the surface morphology of the enlarged cranial structures is sufficiently variable that it shows little convergence among taxa bearing these structures. The sample region of *Casuarius unappendiculatus*, *Numida meleagris*, *Fratercula arctica*, *Anseranas semipalmata*, *Balearica pavonina*, *Bucorvus abyssinicus*, and other growth-bearing taxa collectively produced significantly lower average C-values when compared to each other than among taxa designated as unornamented. However, a subset which included only the taxa with growths extending from the dorsal bar of the premaxilla did appear to be at least slightly convergent with one another. Regardless of the shape of cranial outgrowths, taxa with these structures show correlational trends between skull shape and multiple ecological characters that are statistically different in slope and intercept from those of unornamented birds in our sample. These results suggest the physical environment plays a role in shaping cranial outgrowths, with sexual selection potentially acting within the constraint boundaries of natural selection to produce physically diverse ornaments. Understanding enlarged cranial growths in extant animals can provide a clearer basis for hypotheses about their occurrence in fossil species, and by extension, inform our understanding of interactions between different forms of selection through deep time.

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Colbert Poster Prize Session

**A NEW DIMINUTIVE HETERODONT CROCODYLIFORM FROM THE ALBIAN-CENOMANIAN BLACKLEAF FORMATION OF SOUTHWEST MONTANA**

Allen, Harrison J., Varricchio, David J.

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The Albian-Cenomanian Blackleaf Formation of southwest Montana, particularly the fossiliferous Vaughn Member of the formation, has only recently been explored within a paleontological context and has in terms of macrofossil remains produced little compared to other Cretaceous-aged formations within Montana. However, new discoveries within the Vaughn Member have yielded material of a new crocodyliform, represented by a nearly complete skull, axial and appendicular postcrania, and osteoderms. The new crocodyliform is tiny, with a skull length of ~50 mm but likely represents a subadult individual. Its morphology most closely matches that of the likewise small paralligatorid *Wannchampsus kirpachi* from the Aptian of Texas and the 'Glen Rose Form' from the Aptian-Albian of Texas and Montana. These three taxa may all be closely related to one another and may represent a previously unrecognized subfamily of tiny endemic North American crocodyliforms. The new crocodyliform's heterodont dentition includes four different morphotypes, with standard conical teeth at the anterior portion of the jaws, followed posteriorly by caniniforms, lanceolate pseudoziphodont teeth, and mesiodistally broad, labiolingually compressed teeth at the posteriormost end of the jaws. Teeth matching these posteriormost forms occur in microsites across the Cretaceous of North America, have been tentatively assigned to Bernissartidae, but may instead represent this group of tiny crocodyliforms. The anteriormost dentary teeth are strongly procumbent with wear, similar to those seen in notosuchian crocodyliforms such as *Mariliasuchus* and *Armadillosuchus*. *Mariliasuchus* may have used these teeth for burrowing or foraging through substrate. The occurrence of this new crocodyliform in a formation known for preferentially preserving taxa that interact with the substrate combined with its unusual procumbent dentary teeth, other morphological features, and taphonomic attributes, suggest it may have been preserved within a burrow structure and had specialized burrowing capabilities. The discovery of this new crocodyliform helps not only to refine and reveal more anatomical data for this group of tiny heterodont crocodyliforms but also extends their temporal range within Laramidia and provides taphonomic and morphologic evidence for particular behaviors/ecology of this group.

**Funding Sources** Montana State University Undergraduate Scholars Program Research Grant

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**MAMMALIAN REMAINS FROM THE MIDDLE MIOCENE DEPOSITS OF DHOK BUN AMEER KHATOON, PUNJAB, PAKISTAN**

Ameen, Muhammad[1], Irshad, Faiqa[1], Khan, Abdul Majid[2], Abbas, Sayyed G.[1]

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The Lower Siwaliks of Northern Pakistan are known for occurrence of mammalian remains and the present study is focused on these remains collected from the outcrops nearby Dhok Bun Ameer Khatoon, Chakwal, Punjab, Pakistan. Six specimens that include the upper and lower dentition were collected by surface collection from the outcrops in the vicinity of Dhok Bun Ameer Khatoon that represents Chinji Formation (Middle Miocene) of the Lower Siwalik subgroup. Morphological study of these specimens revealed that three specimens belong to *Listriodon pentapotamiae* (family Suidae), one specimen belongs to *Elachistoceras khauristanensis* (family Bovidae), one specimen belongs to cf. *Samotherium* (family Giraffidae) and one specimen belongs to the order Carnivora gen. and sp. indet. Among these, the genus *Samotherium* has been described for the first time in the Siwaliks. The paleoecological data of Chinji Formation (14.0–11.4 Ma) of Pakistan indicate that the Middle Miocene climate was likely to be wet and humid with strong monsoonal influences and having extensive forest components and mixed vegetation. Biogeographically, the Miocene fauna of the Siwaliks shows similarity with African and Eurasian Miocene fauna. The provided data is useful for the ongoing reassessment of the Chinji Formation mammals.

**Funding Sources** University of Sialkot, Pakistan

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Virtual Posters

### SEXUAL DIMORPHISM REVEALED THROUGH CRANIOMETRICAL ANALYSIS IN *MACACA MULATTA* FROM NORTHERN PAKISTAN

Ammar, Muhammad[1], Iqbal, Ayesha[1], Khan, Abdul Majid[1], Waseem, Muhammad Tahir[2], Naseer, Arshia[1]

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The Rhesus monkey (*Macaca mulatta*) is a significant non-human primate species found in Pakistan's northern areas. *Macaca mulatta* has evolved to survive in a wide range of environmental conditions, depending upon variety of food items and considered as to be the most scattered primate on the earth. Craniometry, the fundamental morphometric approach, has been used to identify differences in the skulls of males and females of this species. Eight preserved skulls—four of each sex—were used in the current study and were acquired from the Zoological Museum at the University of the Punjab, Lahore, Pakistan. A total of 48 skull variables (39 cranial and 9 mandibular) were analyzed to find out the differences in male and female skulls. Most of the skull variables did not show any statistically significant difference. Results indicated that the males of *Macaca mulatta* have larger neurocranium, a slightly broader zygomatic, longer nasal bone, higher as well as longer facial bone and wider ramus of mandible as compared to the female's skull. These craniometric variations may be as a result of several factors including sexual dimorphism, hormonal influence, developmental processes, genetic and environmental factors. This study provides the baseline data of craniometry and insights into sexual dimorphism in *Macaca mulatta* from Pakistan and may have implications for understanding the evolution and ecology of this species.

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Technical Session 18: Synapsids (Saturday, October 21, 2023, 8:00 AM)

### THE GEOGRAPHIC AND STRATIGRAPHIC DISTRIBUTIONS OF PERMIAN DICYNODONTS (THERAPSIDA, ANOMODONTIA) IN THE MID-ZAMBEZI BASIN, ZAMBIA: ESTABLISHING A BASELINE FOR FUTURE RESEARCH

Angielczyk, Kenneth D.[1], Sidor, Christian A.[2], Tolan, Stephen[3], Smith, Roger M.[4], Barbolini, Natasha[5], Beightol, Charles V.[6], Museba, Joseph[7], Nesbitt, Sterling J.[8], Steyer, Jean S.[9], Tabor, Neil J.[10]

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Permian vertebrates were first reported from the Madumabisa Mudstone Formation in the Zambian portion of the Mid-Zambezi Basin in 1959, but only recently have they been the subject of sustained inquiry. Our group performed fieldwork in the Mid-Zambezi Basin in 2011, 2012, and 2014, leading to reports of fragmentary actinopterygians, temnospondyls, dinocephalians, and gorgonopsians; the biarmosuchians *Mobaceras* and *Wantulignathus;* and the dicynodont *Abajudon*. We also collected a number of other dicynodont specimens; documenting their identifications, and geographic and stratigraphic occurrences, is key to facilitating additional paleontological, biogeographic, and biostratigraphic research.

Our fossil localities fall in two main clusters, one in Gwembe District to the southwest and the other in Siavonga District about 50 km to the northeast. In Gwembe, *Abajudon* is the only dicynodont that can be positively identified at localities low in the stratigraphy, where it co-occurs with dinocephalians, suggesting a correlation with the South African *Tapinocephalus* Assemblage Zone and the lower fossiliferous interval of the Tanzanian Ruhuhu Formation. Higher in the stratigraphy, *Abajudon* is absent, *Endothiodon* is abundant, and *Dicynodontoides* is present, similar to the South African *Endothiodon* Assemblage Zone. The high abundance of *Endothiodon* also mirrors the assemblage in the K5b Member of the Mozambican Metangula Graben. An additional set of localities includes *Endothiodon*, cf. *Pristerodon*, cf. *Emydops*, and a new cistecephalid, but occurs in very close proximity to dinocephalian specimens, raising the possibility of a third faunal assemblage or anomalously late surviving dinocephalians. Localities in Siavonga are characterized by abundant *Endothiodon* specimens that co-occur with rarer specimens of *Pristerodon* and *Dicynodontoides*, but no specimens of *Abajudon* have been identified, suggesting a correlation with the *Endothiodon* Assemblage Zone.

Our dicynodont records provide evidence for the presence of multiple tetrapod assemblages in the Zambian portion of the Mid-Zambezi Basin, and establish biostratigraphic and biogeographic links to nearby basins in southern and eastern Africa. Furthermore, combining our Mid-Zambezi records with those from *Cistecephalus* and *Daptocephalus* Assemblage Zone-equivalent strata in the Luangwa Basin shows that the Permian tetrapod record of Zambia is of similar scope in both diversity and temporal extent to that of the main Karoo Basin.

**Funding Sources** NSF EAR-1337291, EAR-1337569; National Geographic CRE 8571-088, 8961-11; Grainger Foundation; Field Museum/IDP, Inc. African Partner's Program

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Preparators' Session (Thursday, October 19, 2023, 8:00 AM)

## STABILIZING WITHOUT COMPROMISING: USING CASTING SAND TO STABILIZE FOSSIL BLOCKS

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In fossil preparation and conservation, there are trade-offs between specimen stabilization and specimen alteration. This is often an issue when dealing with poorly preserved fossils, friable matrix, or specimens and matrix that have degraded over time. Remediation of these conditions requires a thoughtful balance between active structural and chemical intervention and passive cautious monitoring. The current suite of applied methodologies in molecular paleontology makes the latter of these a crucial consideration, as such preparators must be more conscious of specimen alteration during preparation and conservation. Here we present on the application and efficacy of a metal foundry technique known as casting sand or greensand as an easy, inexpensive, reversible, and relatively chemically inert way of stabilizing large cavities, undercuts and cracks within large fossil jackets. Casting sand (i.e., greensand) is a mixture of sand, clay and either oil or water that is mixed to a ratio that produces the desired consistency for a given task. Experimenting with different ingredient ratios, we produced a satisfactory mixture that is malleable when moistened but rigid once dried, allowing for easy removal and reuse. Color differentiation between the casting sand mixture and surrounding matrix can be enhanced with the addition of naturally colored sand (e.g., aquarium sand). Through experimentation, we discovered that differences in clay types (e.g., smectite vs. bentonite) had a nominal difference in how the mixture cured, with the use of bentonite clay resulting in slight shrinkage of the infilling bolus. Our formula consisted of 50% play sand purchased at a local hardware store, sieved to 1.18mm grain size and 50% sodium bentonite clay purchased online and pulverized in a blender for consistency. Tap water was added slowly until the mixture would hold its shape when compressed (~30% volume of dry mixture). As the mixture consists of only sand, clay and water, it is almost completely chemically inert and as such can be applied directly to cracks or voids in fossil specimens with little worry of alteration of the fossils. Additionally, the constituent parts are readily available, inexpensive and can be mixed and stored in large batches for future use. This technique has the potential to also help stabilize jackets in the field.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**ASSESSING ECOLOGICAL RELATIONSHIPS AND STRUCTURES AMONG LATE TRIASSIC VERTEBRATES IN PETRIFIED FOREST NATIONAL PARK**

Apgar, Alexandra D.[1], Tomé, Catalina[2], Moore, Jason R.[3]

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Vertebrate paleocommunities of the Late Triassic Chinle Formation of Petrified Forest National Park (PEFO) in northwestern Arizona remain inadequately understood. Many prior investigations have primarily been qualitative, utilizing functional morphology, inferred diet, and general occurrence patterns observed within the field to build hypothetical trophic structures. While some direct evidence of taxa interaction exists in the form of preserved bite marks, such markings are scarce within the fossil record. The Chinle Formation exposures within PEFO also record a localized faunal and floral extinction known as the Adamanian-Revueltian turnover event, which occurred ~215 MYA. As of yet, it has not been determined whether this turnover dismantled existing faunal structures in addition to impacting taxa, diversity, or whether vacated niches were filled by new taxa.

Utilizing a combination of PAIRS analysis, NMDS ordination, and ANOSIM testing, we examine potential faunal relationships, identify possible broad-scale ecological patterns, and reconstruct hypothetical paleocommunities within the Adamanian and Revueltian faunachrons of PEFO through documented taxa co-occurrence. ANOSIM analyses revealed a temporal faunal shift within the Adamanian. Complementing previously identified potential faunal relationships, interpreted broad-scale patterns of association indicate a possible ecological shift in ontogeny between *Apachesaurus* and *Anaschisma*. Although results seem to indicate similar faunal structures in both the Adamanian and Revueltian, the Adamanian dataset contains multiple significant co-occurrences between aquatic taxa and demonstrates a notable gradient between semi-aquatic and terrestrial taxa, while the Revueltian dataset lacks both aquatic taxa co-occurrences and a large-scale gradient shift. This phenomenon may be potentially driven by the observed paleoenvironmental drying into the Revueltian.

**Funding Sources** UNM Earth and Planetary Sciences Department, UNM Museum Research Traineeship Program (National Science Foundation Grant No. 2021744)

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**DINOSAUR FOOTPRINTS FROM THE UPPER CRETACEOUS NANAIMO GROUP OF VANCOUVER ISLAND, BRITISH COLUMBIA, CANADA**

Arbour, Victoria[1], Ball, David[1], Rombough, Peter[1], Larson, Derek W.[1], Scott, Calla[1], Dickson, Logan T.[2], Cross, Emily[2]

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The Nanaimo Group of Vancouver Island and the Gulf Islands of British Columbia, Canada, was deposited in a forearc basin between the Wrangellia Terrane and western North America during the Turonian to Maastrichtian. Although much of the group was deposited in nearshore or deep marine paleoenvironments, several formations in the Lower Nanaimo Group were deposited in non-marine environments and can preserve excellent plant fossils. Here we report the first evidence for dinosaur footprints within the Nanaimo Group, from a site located near Nanaimo, BC. The tracks occur within the Early or Middle Campanian Protection Formation, which was most likely deposited in a coastal plain setting. The tracks are impressed in mudstones and most are preserved as weathered, honeycomb-eroded sandstone casts with deformed mudstone rims. At least 25 tridactyl tracks were

observed in an approximately 150 $m^2$ area of the modern intertidal zone, and there does not appear to be a preferred orientation to the tracks. The majority of the footprints are approximately as wide as they are long, have relatively blunt toe tips, and have either rounded or bilobed heels, which suggests these are attributable to *Hadrosauropodus* sp. and hadrosaurid trackmakers. These typically range from 30 to 45 cm in length, consistent with sizes attributed to subadult hadrosaurs elsewhere in North America; a few poorly preserved tracks in an isolated cluster away from the main concentration of tracks are up to 70 cm long. One footprint has narrow digits, is significantly longer than wide, has slightly pointed toe tips, and a V-shaped heel. This track may have been made by a theropod trackmaker, potentially a juvenile tyrannosaur or an ornithomimid. Only two dinosaurian skeletal fossils have been reported from the Nanaimo Group to date – an ornithomimid caudal vertebra and a large theropod femur – both from marine sediments of the younger Cedar District Formation. The new tracksite reported here thus represents the first occurrence of ornithischians and the first autochthonous dinosaur fossils from the Nanaimo Group.

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**STRATIGRAPHIC OCCURRENCES OF THE CRETACEOUS SHARK GENUS *CRETODUS* (LAMNIFORMES: PSEUDOSCAPANORHYNCHIDAE) IN KANSAS, USA, AND THEIR ECOLOGICAL IMPLICATIONS**

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*Cretodus* is an extinct lamniform shark genus that is known from the Albian–Santonian marine deposits nearly worldwide. Much work is still needed to decipher the species-level taxonomy, there are three known groups of *Cretodus*: the *longiplicatus*/*semiplicatus*-grade, the *gigantea*/*houghtonorum*-grade, and the *crassidens*-grade. FHSM VP-19857 is a tooth of *Cretodus* sp. housed in the Sternberg Museum of Natural History in Hays, Kansas, USA. It occurred from the upper part of the Fairport Chalk Member (middle Middle Turonian) of the Carlile Shale in northwestern Hamilton County, Kansas. The specimen is significant because it represents the youngest occurrence of the *longiplicatus*/*semiplicatus*-grade *Cretodus* in Kansas, where previous records of this grade in Kansas and adjacent states were confined to the mid–late Cenomanian strata (Graneros Shale and basal Greenhorn Limestone). Specimens of *Cretodus* do occur from above the Fairport Chalk, but they are represented by the *gigantea*/*houghtonorum*-grade forms from the upper part of the Carlile Shale (Blue Hill Shale and Codell Sandstone). Therefore, the present fossil record demonstrates that the *longiplicatus*/*semiplicatus*-grade *Cretodus* persisted and occasionally ventured into the middle of the Late Cretaceous Western Interior Seaway of North America as late as the mid-Turonian, and that the stratigraphic occurrences of the grade in Kansas do not overlap with those of the *gigantea*/*houghtonorum*-grade. Although no decisive record of the *crassidens*-grade *Cretodus* exists in Kansas, more significantly, the present stratigraphic occurrences of *Cretodus* in Kansas, particularly the lack of records in deposits formed at offshore, deeper water environments (upper Greenhorn Limestone–lowermost Carlile Shale), supports the hypothesis that *Cretodus* (at least the *longiplicatus*/*semiplicatus*-grade and *gigantea*/*houghtonorum*-grade *Cretodus*) preferred nearshore shallower waters.

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Technical Session 11: Archosaurs (Friday, October 20, 2023, 8:00 AM)

**INSIGHTS INTO SHUVOSAURID (PSEUDOSUCHIA: POPOSAUROIDEA) ANATOMICAL VARIATION INFERRED FROM A NEW TAXON FROM THE UPPER TRIASSIC CHINLE FORMATION OF PETRIFIED FOREST NATIONAL PARK**

Armour Smith, Elliott, Sidor, Christian A.

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Shuvosauridae is a clade of paracrocodylomorph pseudosuchians known from the Upper Triassic. The earliest occurrence of the clade is *Sillosuchus longicervix* from the Carnian Ischigualasto Formation of Argentina, indicating a likely southern Pangean origin for the family. There are currently two named shuvosaurids from North America: *Shuvosaurus*, from the Norian of Texas, and *Effigia*, from the Carnian of New Mexico. We present information on a new species of shuvosaurid from the Upper Triassic Chinle Formation of Petrified Forest National Park (PEFO), Arizona. The material occurs in a bonebed stratigraphically positioned near the base of the Sonsela Member, within the Jim Camp Wash beds. Radiometric dating constrains the site to approximately 214–218 Ma. The bonebed preserves disarticulated material of at least 22 taxa including theropods, aetosaurs, azendohsaurs, drepanosaurs, metoposaurs, chondrichthyans, coelocanthiforms, and actinopterygians. The new shuvosaurid is represented by much of the skull, mandible, vertebrae, and appendicular skeleton, with over 700 elements currently cataloged. Autapomorphies for the new taxon include a maxilla with a reduced body and a thin and delicate anterior process, as well as a dorsal process with a posteroventral inflection at its midpoint. Autapomorphies of the quadrate include an expanded pterygoid flange with a lateral ridge and a tapered ventral process. An autapomorphy of the pterygoid includes a robust, crescent-shaped lateral process that tapers laterally. The PEFO taxon is distinguished from *Effigia* by its reduced mandibular fenestra, like the condition in *Shuvosaurus*. These anatomical features suggest the PEFO shuvosaurid material represents a new species, but this hypothesis awaits formal phylogenetic testing. Skeletal features suggest much of the material referred to the new shuvosaurid represents skeletally immature individuals. For example, the new taxon has an unfused mandibular symphysis and an angular not fused to adjacent mandibular elements, unlike the condition in *Effigia*. Also, the laterosphenoid is not fused to the skull roof, and the parietals are only partially fused along the midline and do not form a pronounced sagittal crest. The PEFO shuvosaurid occurs stratigraphically between the previously described shuvosaurid genera from North America, suggesting that shuvosaurids were persistent components of terrestrial faunas for nearly the entire Norian.

**Funding Sources** Research supported by the Evolving Earth Foundation

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Virtual Posters

### THE EVOLUTION OF THE AIR SAC SYSTEM IN NON-AVIAN THEROPOD DINOSAURS: EVIDENCE FROM THE UPPER CRETACEOUS OF MADAGASCAR

Aureliano, Tito, Ghilardi, Aline M.

Diversity, Ichnology and Osteohistology laboratory (DINOlab - UFRN), Natal, Brazil

Recent evidence suggests that the invasive air sac system evolved at least three times independently in avemetatarsalians: in pterosaurs, sauropodomorphs and theropods. Data from sauropodomorphs showed that the pneumatic architecture in vertebrae first developed in camellate-like trabeculae in the Triassic, later in camerate systems in the Jurassic, and finally camellate tissue in the Cretaceous. This evolutionary trajectory has robust support from sauropodomorph taxa. However, the evolution of pneumatic tissues in Theropoda is less understood. We reanalyzed the previously described computed tomography of *Majungasaurus* (Maj) and *Rahonavis* (Rah), now using densitometry in false colors to differentiate the pneumatic architecture along the presacral axial skeleton of late Ceratosaurians and Paravians. Maj vertebrae presented a polycamerate architecture in both the neural arches (n) and most of the centra (ce), except for the mid-dorsal centrum, which presented a dense apneumatic trabecular array. The posterior cervical ce presents small circular chambers ventrally, a condition previously only seen in neosauropods. The trabecular walls in pre- and postzygapophyses (prz and poz) expand into several larger chambers resembling a ‘butterfly pattern’ in dorsal view. The neural spine (s) of Maj is apneumatic in contrast with the condition seen in Rah, which presents elliptical chambers elongated ventrodorsally. The pneumatic signatures in Rah are overall more intense than in Maj. Chambers in prz and poz present more subdivisions, and yet less complexity than the trabeculae in the ce. The ce present polycamellate architectures organized as ellipsoid fractals, with a large horizontally elongated chamber at the middle. Finally, the microanatomy of Maj and Rah revealed an increase in pneumatic complexity in paravians in comparison with the ceratosaurians. Considering that late abelisaurids inherited from their ceratosaurian ancestors some apneumatic elements such as the s and some ce, paravians took a different trajectory towards the full pneumatization of the axial skeleton, a characteristic that provided paravians an advantage in gliding and flying. Also, unlike Sauropoda, pneumaticity in Theropoda seems to have developed increasing chamber volumes towards paravians. Similar studies on early Theropoda taxa are needed to elucidate whether this was an evolutionary trend.

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Preparators' Session (Thursday, October 19, 2023, 8:00 AM)

**ADVANCES IN 3D SURFACE SCANNING: MOBILE DEVICE APPLICATIONS SET A NEW STANDARD FOR THE DIGITIZATION OF FOSSILS AND MUSEUM ARTIFACTS**

Avrahami, Haviv M., Herzog, Lisa

Paleontology, NCMNS, Garner, North Carolina, United States

Over the last decade, the utilization of 3D surface scanning in vertebrate paleontology has become an increasingly important method for data collection, visualization, and 3D printing. Although still in its infancy, the field of surface scanning has seen a proliferation of commercial and open-source software and devices. Here we report on a series of quantitative and qualitative comparisons between a variety of 3D scanning approaches that included the Artec Spider/Leo hand-held commercial scanners processed with Artec Studio software, the desktop photogrammetry software Agisoft Metashape, and mobile device applications using Object Capture API and/or LiDAR (Capture3, Hedges, Kiri Engine, Luma, Metascan, Polycam, Qlone, RealityScan, and ScandyPro). Each method was evaluated quantitatively and qualitatively across a wide set of metrics including processed 3D mesh scaling/measurement/resolution accuracy, texture/color mapping, scannable object size ranges, workflow ease/speed (capture, upload, and processing), real-time scanning feedback, reprocessing availability, cloud vs. offline device processing capability, availability of exportable formats, raw data/picture export availability, object/background masking features, cost, accessory equipment needed, data security, and customer/community support.

We find that Metascan outperforms all tested approaches in nearly every category and is the only program that allows the export of original images taken within the application. However, it is only available on iOS devices from 2015 or later. The latest iPhones outperform the latest iPad Pros (main camera sensors with 48 MP vs 12 MP), and the smaller size of iPhones provides a wider range of navigation around small and complex specimens. When paired with a Bluetooth camera shutter remote, a 10 cm diameter ring light, and a clip-on 15x macro lens, texture and geometric mesh resolution in the millimeter to the submillimeter size range was achieved, allowing for the 3D digitization of vertebrate microfossils, oviraptorosaur eggshell ornamentation, ornithopod orbital rim scalloping, and pathological tyrannosaur bone surface texture. Using these parameters, full 360° scans were achieved in as little as five minutes, allowing for the bulk processing of multiple specimens in rapid succession. Finished and correctly auto-scaled models can be batch uploaded directly from the device to most cloud storage providers or downloaded directly from the Metascan web program.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**NEW ADDITIONS TO THE EARLY DIVERGING ORNITHISCHIAN *ZEPHYROSAURS SHAFFI* FROM THE CRETACEOUS CLOVERLY FORMATION OF NORTH AMERICA**

Avrahami, Haviv M.[1], Hauser, Claire M.[2], Zanno, Lindsay E.[1]

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*Zephyrosaurus shaffi* is an early diverging ornithischian dinosaur from the Aptian- to Cenomanian-aged (~124-98 Mya) Little Sheep Mudstone and Himes members of the Cloverly Formation of the Western USA. Described initially from an incomplete skull and a few vertebral elements, subsequent expeditions to the Cloverly Formation have recovered additional materials from the cranial and postcranial skeleton that have been referred to this taxon. These materials have yet to be described; however, they have been used as part of the *Z. shaffi* OTU in a number of recent phylogenetic datasets. These analyses have consistently recovered *Z. shaffi* as a member of Thescelosauridae, specifically, Orodrominae. Here we describe a number of new elements and reassess the original holotype material, documenting a mosaic of phylogenetically important neornithischian and transitional neoceratopsian features.

A new, well-preserved, complete humerus has a caudally inclined proximal head with a lateral surface that is extensively expanded rostrocaudally, forming a flat surface confluent with a prominent deltopectoral crest. This condition is transitional between the thescelosaurid *Orodromeus makelai* and the neoceratopsian *Protoceratops andrewsi*. Three partially preserved scapulae differ in morphology from other thescelosaurids, having a robust neck relative to the distal blade, being much more straight, and lacking a prominent caudal deflection. A partially preserved strap-like ilium is dorsoventrally low in contrast to the taller ilia of *O. makelai* and *Thescelosaurus neglectus*. A new metatarsal V is robust and paddle-shaped, a condition shared by the neoceratopsians *Auroraceratops rugosus* and *P. andrewsi*, in contrast to the more slender and elongate condition in the thescelosaurid *Oryctodromeus cubicularis*. Four jugals are preserved from three different localities, each possessing a distinct caudolaterally directed tab-like process. This process is shared with only *O. makelai* and two heterodontosaurids (*Heterodontosaurus tucki* and *Manidens condorensis*). A new, 3D cranial reconstruction of the holotype specimen reveals a parietal with a uniquely dorsally flaring caudolateral border, in contrast to the flatter dorsal margins seen in other thescelosaurids. These new materials of *Z. shaffi* illuminate a suite of transitional characters important for understanding the unstable relationships of early diverging ornithischians.

**Funding Sources** This material is based upon work supported by the National Science Foundation award #1925973 to LZ

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**HORN SIZE VARIATION WITH LATITUDE IN BISON**

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Ecometrics is a method used to evaluate the relationship between the observable traits of organisms and environmental parameters. By selecting traits whose structures are tightly related to their functions, and whose functions directly interact with the environment, it is possible to estimate climatic and other environmental parameters (e.g., mean annual temperature, and dominant local vegetation type) from morphology. Horns may be one such trait because they are composed of living tissue and have thermoregulatory functions that constrain their morphology; larger horns have a larger surface area through which body heat may be lost to the environment, which can be problematic in colder environments, where lost body temperature can prove detrimental—even life-threatening—to the individual. Given that increased thermoregulatory demand may ultimately reduce overall fitness, we expect animals from colder environments to possess smaller horns with lower surface areas. This prediction is supported by a correlation between horn size and latitude for 15 species of bovid, with larger horn sizes observed in tropical and smaller horns in temperate regions. However, the phenomenon has never been studied within a species across a continuous latitude. We aim to test for a relationship between horncore size (horncore length, circumference, and surface area) and climate (i.e., mean annual temperature, and precipitation) for the North American bison (*Bison bison*) by analyzing their horn morphology across the latitudes of 35°–65°N. Although not statistically significant ($p = 0.427$), preliminary regression analyses suggest a negative correlation between horn size and latitude in bison from 50°–55°N and 60°–65°N ($n = 37$), possibly indicating that bison horns may be used as climate proxies for the past. Ongoing work is aimed at testing for a relationship of horncore size with mean annual precipitation, temperature, and dominant local vegetation type.

**Funding Sources** Natural Sciences and Engineering Research Council of Canada; Carleton University

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Virtual Posters

**THE FIRST APPARENCE OF A SMALL-SIZED BEAVER (CASTORIDAE, MAMMALIA) FROM THE LATE MIOCENE (EARLY TUROLIAN) OF MOLDAVIAN PLATFORM, EASTERN ROMANIA**

Badea, Dumitru D., Branzila, Mihai, Ratoi, Bogdan Gabriel

Geology, Alexandru Ioan Cuza University of Iasi, Iasi, Iași, Romania

Castorid dental material is described from four fossiliferous deposits from the Late Miocene (Early Turolian) of Moldavian Platform, Romania. The material is represented by six isolated teeth and was assigned to *Euroxenomys minutum* and *Trogontherium minutum rhenanum* species. It is the first record of the species in Romania and represents

an important contribution for the study of Eurasian Miocene beavers.

The family Castoridae is a clade of rodents belonging to the order Rodentia (Mammalia). This family is represented by small-sized beavers *Euroxenomys minutus*, *Steneofiber eseri*, medium-sized ones *Chalicomys jaegeri* and *Steneofiber depereti* and large-sized beavers *Anchitheriomys suevicus*. In Europe the beavers belonging *Euroxenomys* and *Trogontherium* genera are known from many localities from Austria, Bulgaria, France, Czech Republic, Germany, Greece, Portugal, Switzerland, Moldavia, Poland, Rusia, Spain, Turkey, Ukraine, Hungary and now also Romania. The oldest occurrence of the *Euroxenomys minutum* species is reported in Oellingen (MN 3) locality from Germany and the newest one is reported in Polgardi (MN 13) locality from Hungary. Fossil representatives of the genus *Trogontherium* are also found in the Early Pliocene, including in Romania (Mn 14/15).

The main aim of the present work is to compare the discovered material with the material mentioned in other Late Miocene localities from Europe and the interpretation of the paleoenvironment in which these beavers evolved. In order for the morphological elements of the teeth to be as visible as possible, photographs were taken with the help of the Scanning Electron Microscope, model Hitachi S-3400N, the metallization being made with gold.

This work highlights four new fossiliferous points from the Upper Miocene of Romania where fossil remains belonging to the Castoridae family were identified. This could be of interest for future studies based on the interpretation of the evolution of beavers in Eurasia.

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Colbert Poster Prize Session

**REFINING FOSSIL BAT OCCURRENCE AGES TO STUDY RATES OF SPECIES DIVERSIFICATION NEAR THE EARLY EOCENE CLIMATIC OPTIMUM**

Baez, Justin R., Jones, Matthew F., Upham, Nathan S.

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Current evidence suggests that the transition from stem to crown bats occurred near the Early Eocene Climatic Optimum (EECO) ~53-49 Ma, which saw a dramatic increase in temperatures globally. To test whether this transition to crown bats occurred in either direct relationship to the EECO, or as a result of it, higher resolution occurrence dates for fossil bats are needed. Starting with 1,565 fossil bat occurrences downloaded from the Paleobiology Database (PBDB), we newly constrained the geologic ages for 205 fossil occurrences, primarily at the genus and species taxonomic ranks, that previously had age intervals listed as > 5 Ma in PBDB. In many cases, fossil occurrences with epoch-scale stratigraphic ages in the PBDB could be confined to smaller time intervals by using the land mammal stages or updated ages for the fossil-bearing geological units referenced by the source literature. Of those fossils with updated ages, the average age reduction was 76.6%. About 42% of those updates resulted in fossil age intervals of < 1 Ma. We then used the refined fossil bat occurrence ages to estimate rates of lineage origination and extinction using PyRate – a software for analyzing rates of evolution using fossil occurrences. Initial results demonstrated an increase in net diversification from 0.9 to 1.5 species/Ma beginning ~49 Ma and peaking ~47 Ma. The pulse returned to near background diversification rates beginning ~45 Ma, which persisted through the Miocene. Starting ~ 11 Ma, we detect a reduced rate of lineage extinction, which manifests as a gradual increase in rates of net diversification toward the present. Overall, our results indicate that levels of bat speciation and extinction were highest in the early Eocene close to the timeframe of the EECO. However, greater integration of phylogenetic information from bat fossils and molecules will be needed to test for the possible causal relationship between the stem-to-crown transition of bats and the EECO. Our study supports the invaluable contribution of fossil data to understanding the evolutionary radiation of bats.

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Technical Session 5: Ungulates (Wednesday, October 18, 2023, 1:45 PM)

**DIVERSE ARTIODACTYLS FROM THE MIDDLE EOCENE OF THE ERLIAN BASIN, INNER MONGOLIA, CHINA**

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Artiodactyls are relatively diverse and abundant in the Eocene of Europe and North America, whereas their diversity is low in the current fossil record from Asia, especially the Mongolian Plateau and Central Asia. Furthermore, spatial and temporal distributions of the Eocene artiodactyls from Asia are variable. Previously known Eocene artiodactyls from the Erlian Basin of the Inner Mongolia were mainly medium-sized entelodontids, *Gobiohyus*, and primitive ruminants. Here we report diverse small- to medium-sized assemblages of artiodactyls from the Arshantan through the Sharamurunian ALMAs (Asian Land Mammal Age). A new species of *Paraphenacodus* and a taxon probably ancestral to *Gobiohyus* are discovered from the Arshanto Formation (early middle Eocene). Two new genera and three new species of Tapirulidae and a new lantianiine are recovered from the Irdin Manha Formation and its equivalent stratum. A new and derived tapirulid is from the Shara Murun Formation. These new species are mostly represented by fragmentary but diagnostic materials. Analyses of these new material allow us to reach three preliminary conclusions: First, *Paraphenacodus* and an ancestral form of *Gobiohyus* are the first records of artiodactyls from the Arshantan ALMA in China. Second, *Paraphenacodus*, characterized by having bunodont teeth, weak cristids, and considerably enlarged m3 hypoconulid lobe, is likely derived from *Tsaganohyus*, although it also bears some similarities to European early cebochoerids. Finally, the relatively higher diversity of basal tapirulids with selenodont teeth from the Irdin Manha Formation indicates that the previously recognized European endemic *Tapirulus* probably originated from Asia and that mammalian faunal exchanges had taken place between the two continents during the middle Eocene. These new Eocene artiodactyls from the Erlian Basin indicate that Eocene artiodactyls in Asia are more diverse than previously thought and shed light on the origin of early artiodactyls, including some European endemic species.

**Funding Sources** Strategic Priority Research Program of CAS (XDB26000000), the NSFC (42272011), Frick Funds from the Division of Paleontology, AMNH, and a Discovery Grant from the NSERC.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**FAST, CHEAP, OR GOOD – PICK TWO: TRADE-OFFS IN 3D MODELING TECHNIQUES FOR PALEONTOLOGICAL SPECIMENS**

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Although 3D modeling provides paleontologists with a number of advantages over traditional 2D methods of fossil digitization, differentiation between 3D methods and their best practices is complicated by the difficulty of comparing the advantages and disadvantages of each method for specific applications. To address this, we compared five common scanning techniques: 1) LiDAR via smartphone apps (Scaniverse, PolyCam); 2) smartphone photogrammetry apps; 3) professional photogrammetry software (Agisoft Metashape Pro) paired with a commercially available mirrorless camera (Nikon Z50); 4) 3D surface scanning (Artec Spider); and 5) computed tomography (CT) scans (GE phoenix v|tome|x s 240 scanner, VG Studio Max 3.4 software). We ranked each method according to its cost, scanning time, precision (here measured by resolution), accuracy, difficulty, and its ability to scale with both specimen size and complexity. To assess these methods for vertebrate paleontological research, we created a matrix of three common paleontological specimen types: teeth, crania, and trace fossils. This range of types allowed us to assess each modeling method in both pure 3D reconstruction and in ascertaining relief along a mostly flat surface (“2.5D”), crucial to the study of ichnofossils. By selecting a broad size range for each type of specimen, we were able to more thoroughly compare the trade-offs of each method. Although CT remains the gold standard in both precision and accuracy, it is significantly more costly and time-consuming than any other method. (It is also the only method that can reveal internal structure and that cannot provide color information.) We present a decision framework between 3D surface scans and photogrammetry techniques for specimens of different sizes and complexities and demonstrate the potential for high-sensitivity data collection with consumer-grade camera technology. LiDAR and photogrammetry via personal smartphones, unheard of even five years ago, is a promising and accessible method for producing affordable models, but the techniques now available are limited. Nevertheless, this may prove a cost- and time-effective method for field capture in the near future. We plan additional functional testing via geometric morphometric methods to further assess our model outputs and compare their utility in practice.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**A DEEP TIME PERSPECTIVE ON BITE FORCE: A CASE STUDY IN GEOMORPH RODENTS**

Ball, Madeline P.[1], Poorboy, Dylan M.[2], Socki, Francesca[3], Calède, Jonathan J.[1]

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Bite force is associated with a variety of behavioral and ecological factors in extant organisms including locomotion, diet, reproductive ecology, and size. As such, it provides an opportunity to inform the ecology of fossil taxa. Geomorph rodents, the clade comprising pocket gophers (Geomyidae) as well as kangaroo rats and their relatives (Heteromyidae) are an ideal study system to explore bite force over evolutionary timescales. They are taxonomically and ecomorphologically diverse, have a rich fossil record, and there exists a phylogenetic framework integrating living and extinct species. In this study, we use bite force to inform the impact of adaptive and nonadaptive processes on geomorph evolutionary ecology. We estimated the bite force of 65 extant and 52 fossil geomorph species using two measurements of the lower incisor as well as the lengths of the crania or toothrows for 899 specimens.

We find that most differences in bite force among extant species are due to body size, but some differences are associated with diet and locomotion; there is little evidence for sexual dimorphism in bite force when accounting for size. Our comparison of extant chisel-tooth and scratch-digging gophers shows that bite force constrains the ecology of burrowing rodents. Therefore, we make locomotory inferences for 11 species of fossil gophers in the subfamily Entoptychinae. We used an ancestral character state reconstruction and a phylogenetic ridge regression to map the evolution of bite force and analyze rates of evolution and phenotypic change from the mid-Eocene to the modern day. The common ancestor of all geomorph rodents displays an intermediate bite force. Both the Florentiamyidae, an extinct family sister to the crown group, and the family Heteromyidae show decreased bite forces compared to that common ancestor. The decrease in heteromyids coincides with a significant change in evolutionary rate, potentially reflecting a trade-off between bite force and cranial evolution, particularly auditory bulla inflation. Bite force evolution in Geomorpha follows an early-burst model, which may be attributable to ecological diversification 30 Ma. Our results reveal a complex evolutionary pattern, suggesting the need for further analyses, including studies of incisor procumbency and florentiamyid ecology. Investigations of bite force in other burrowing rodent clades using this approach may enable a more comprehensive evaluation of the evolution of fossoriality in Rodentia.

**Funding Sources** The Ohio State University Marion campus, College of Arts and Sciences, and Undergraduate Research Apprenticeship Program as well as the Paleontological Society.

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Technical Session 1: Sauropod & Ornithischian Dinosaurs (Wednesday, October 18, 2023, 8:00 AM)

**EXPLORING THE ROLE OF EVOLVING FOREST COMPOSITION IN SHAPING DINOSAUR DIVERSITY PATTERNS IN THE CRETACEOUS OF NORTHERN ALBERTA, CANADA**

Bamforth, Emily

Philip J. Currie Dinosaur Museum, Wembley, Alberta, Canada

Fossil plant assemblages are critically important for recreating paleoenvironments and understanding the paleoecology of vertebrate communities. In this study, six new macrofloral sites from northern Alberta, Canada, as well as a review of past studies of Albian floras and faunas from the same region, help to shed light on the potential role forest composition had in driving dinosaur ecology and evolution. Previous studies of the macroflora from the Albian (109 – 107 Ma) Gates Formation of northeast Alberta, and the stomach contents (cololite) of the nodosaur *Borealopelta* found in the coeval marine Clearwater Formation, suggest these forests were dominated by conifers, seed ferns, horsetails, and cycads. The dominant megaherbivores at this time, as evidenced by the body fossils and footprints, were ankylosaurians. While the vertebrate fossil record of the Cenomanian (96 – 93 Ma) Dunvegan Formation of northwest Alberta is less well known, the dinosaur faunas are similarly dominated by ankylosaurians. However, the macrofloral record from the same formation suggest that these animals were living in significantly different forests. A new macrofloral site from the Dunvegan Formation, the McCoy Leaf Site, is dominated by a diverse angiosperm leaf assemblage with a small number of *Metasequoia* fronds. The only other known macrofloral site from this formation in northeast British Columbia is also dominated by angiosperms and conifers, with little evidence of the seed ferns present in the Abian floras. By the late Cretaceous, the ankylosaurians were gone and the forest composition had changed fundamentally. The dominant megaherbivores in the Campanian (~76 –74 Ma) Wapiti Formation of northwest Alberta were hadrosaurs and, to a lesser extent, ceratopsians. Five newly discovered palaeofloral sites from the Wapiti Formation imply forests whose canopies were made up of *Metasequoia* and *Parataxodium* confers, and with diverse understories made up primarily by broad-leafed angiopserms and gingkoes. While the replacement of ankylosaurians by hadrosaurs as the dominant megaherbivores during the middle and late Cretaceous could be attributed to several factors, the structure and diversity of forests, as their main source of food, could have been a major driver. Ongoing, small-scale studies such as this one in northern Alberta may help to elucidate the extent the role plant communities had in influencing trends in dinosaur ecology and evolution.

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**MAMMOTH VS. ELEPHANT: INSIGHTS INTO DIETARY VARIABILITY THROUGH TIME**

Barrett, Chase A.[1], Pardi, Melissa I.[2], Mueller - Filipes, Elsa[1], DeSantis, Larisa[1]

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Proboscideans, including mammoths, are a component of many diverse herbivore assemblages. Within communities, resource partitioning reduces competition and facilitates coexistence. Stable isotope analysis of $\delta^{13}C$ is frequently used as a dietary proxy distinguishing the consumption of C3 and C4 plant resources in the fossil record. Because there are geographic constraints to using $\delta^{13}C$ to infer the relative use of grass and browse, dental microwear texture analysis (DMTA) is also used to characterize degrees of browsing, mixed-feeding, and grazing in many fossil taxa, with ground truthing in living analogs. However, the large size of mammoth teeth distinguishes them from many taxa that have been better studied using dental microwear. Here, we present a comparative sample from a living modern analog, the African bush elephant, to serve as a frame of reference for interpreting mammoth DMTA. The comparative sample consists of teeth from 11 individuals of *Loxodonta africana* that were culled as part of management activities in Kruger National Park (KNP) in 1993 (CITES permit certificate no. 780873) and are curated at the Illinois State Museum. These individuals originated from the arid bushveld of the Northern region of KNP at the beginning of the dry season. Elephants in the northern regions of KNP consume a mixed diet of approximately 40% grass during the dry season and 50% grass during the wet season. The temporal and regional constraints of this sample provide an opportunity to characterize the microwear of animals whose diets and environment are well understood. Teeth with active wear were molded, and casts were analyzed for DMTA. The KNP sample was then compared to mammoth DMTA data from previously published studies. Microwear of *L. africana* exhibits similar DMTA attribute values as observed in mammoths from regions previously examined. Comparisons with fossil assemblages reveal few statistically significant differences in microwear between mammoth and KNP elephants, with the exception of mammoths from Cypress Creek, TX, Ingleside, TX, and Leisey Shell Pit 1A which have significantly lower complexity values than modern African bush elephants. Variation and breadth of DMTA from mammoths are similar to a temporally and geographically constrained population of *L. africana*. Fossil assemblages, despite time averaging, are not inherently more variable than modern populations.

**Funding Sources** National Science Foundation and Vanderbilt University

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**ONTOGENETIC STATUS OF A PHYTOSAUR (REPTILIA: ARCHOSAURIFORMES) SPECIMEN FROM THE UPPER TRIASSIC SLOAN CANYON FORMATION OF THE DRY CIMARRON VALLEY, OKLAHOMA, U.S.A, AS REVEALED BY FIBULAR OSTEOHISTOLOGY**

Barta, Daniel E.

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Phytosauria is a clade of exclusively Triassic archosauriform reptiles. Despite their abundance and wide distribution, knowledge of phytosaur ontogeny remains limited owing to the rarity of immature specimens and histological studies compared to other reptile clades. Therefore, hypothesized ontogenetic transformations of phytosaur cranial morphology are rarely calibrated to relative or absolute ages derived from postcranial osteohistology. I use osteohistological data to test my initial ontogenetic assessment of a partial, possibly immature phytosaur skull and associated postcrania (OMNH 02939) from the Upper Triassic Sloan Canyon Formation of Oklahoma, U.S.A. My previous preliminary phylogenetic analysis suggests that OMNH 02939 can be assigned to *Machaeroprosopus* sp.

The left fibula of the specimen was molded and cast prior to removal of a midshaft fragment, which I embedded in clear polyester casting resin. I used cyanoacrylate to mount a wafer cut from the midshaft on a plexiglass slide prior to grinding and polishing to optical transparency.

The primary bone of the fibular midshaft is predominantly parallel-fibered, with some woven bone present. Both primary and secondary osteons are almost all longitudinally oriented. The inner cortex is overprinted by secondary osteons, indicating partial remodeling. The remaining primary bone in the outer cortex is interrupted by at least five lines of arrested growth (LAGs) (some are double or triple LAGs counted as one). OMNH 02939 lacks the closely spaced LAGs of an external fundamental system, indicating that it was still growing at the time of its death.

The axial neurocentral suture is open, as expected given the caudal to cranial fusion sequence of phytosaur neurocentral sutures. The interfrontal suture of OMNH 02939 is visible and appears partially open along both its dorsal and ventral surfaces, indicating that this suture remained open (or reopened) years after the individual hatched. This contrasts with *Alligator mississippiensis*, in which the interfrontal suture may close prior to hatching. Retention of open interfrontal and other cranial sutures throughout ontogeny may be typical for phytosaurs, but extensive growth series and detailed inter- and intraspecific comparisons are needed to test this. Integrating bone histology with other maturity assessment criteria contributes to an emerging ontogenetic framework that will help untangle sources of anatomical variation among phytosaur specimens.

**Funding Sources** Funding: Oklahoma State University Center for Health Sciences

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Symposium Session: Theropod Flight Origins (Thursday, October 19, 2023, 1:45 PM)

**MORPHOLOGY AND PNEUMATICS OF A PTEROSAUR WING (PTEROSAURIA: ORNITHOCHEIROMORPHA) FROM THE ELRHAZ FORMATION (APTIAN-ALBIAN) OF NIGER**

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The middle portion (radius to second wing phalanx) of an articulated pterosaur forelimb was recovered in the Gadoufaoua region of the Elrhaz Formation of Niger. The specimen, which preserves the pteroid, all of the carpals and metacarpals, and most of the phalanges of the minor digits, has a restored estimated wing length of 2.4 meters for an estimated wingspan of ~5 meters. Computed tomographic scans of the wing bones reveal open sutures between elements known to fuse with maturity in pterosaurs. In particular, the suture separating the extensor tendon process on the wing finger first phalanx and that between the two carpals of the proximal syncarpal remain open, suggesting the specimen was not fully mature. The shallow concavoconvex articulations between the forearm (radius, ulna) and the proximal syncarpal are preserved as well as joint surfaces between the distal syncarpal, preaxial carpal and pteroid. All four metacarpals are preserved in place, the second and third approximately one-third the length of the first and fourth. The proximal phalanges of first and second digits have pneumatic foramina on the ventral aspect of the base of the phalanx. Ginglymoid interphalangeal articulations are visible in the minor digits. Other notable features include the dorsal position of the large foramen on the extensor tendon process, which is more often located on the ventral side. We use 3D renderings of the mid-wing skeleton of this Niger pterosaur to consider the neutral orientation of the minor digits in flight and how these digits may relate to forelimb footprints from Late Cretaceous pterosaur trackways.

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Technical Session 9: Sauropsids (Thursday, October 19, 2023, 1:45 PM)

**LONGER COCHLEAE DO NOT RELATE TO HIGHER FREQUENCY HEARING IN SAUROPSIDS**

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The basilar membranes of nearly all amniotes encode frequencies in a similar manner, with lower frequencies affecting the distalmost portions of the membrane and higher frequencies affecting the membrane more proximally. In mammals and birds, longer basilar membranes are associated with increased sensitivity to low frequency sounds (negative correlation between membrane length and hearing sensitivity), but longer membranes have frequently been considered to relate to higher frequency sensitivity in non-avian reptiles (positive correlation). Re-examination of the data used to derive the latter relationship reveals that, in all groups, there is either a negative correlation between membrane length and frequency sensitivity (as in mammals and birds) or no clear relationship (non-avian reptiles); in no case is a positive correlation evident. The previously assumed positive relationship between basilar membrane length and high frequency hearing in reptiles is the result of analyses being conducted at too broad of a phylogenetic scale. Therefore, hearing estimation methods that predict a positive correlation should not be used, and cochlear elongation in any tetrapod lineage should be assumed to relate to a lowering of the low frequency threshold, not to a raising of the high frequency threshold or of the frequency of best hearing.

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Technical Session 17: Afrotheria & Mammal Macroevolution (Saturday, October 21, 2023, 8:00 AM)

**NEW DATA ON THE EARLY EVOLUTIONARY HISTORY OF BALKANATOLIAN EMBRITHOPODA (MAMMALIA, PAENUNGULATA) FROM THE ÇIÇEKDAĞI BASIN, CENTRAL ANATOLIA**

Beard, K. Christopher[1], Miller, Kristen[1], Rust, Kathleen L.[1], Ocakoglu, Faruk[2], Coster, Pauline[3], Licht, Alexis[4], Métais, Grégoire[5]

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Embrithopoda is an extinct clade of placental mammals that includes the iconic, graviportal taxon *Arsinoitherium*. Embrithopods have long been regarded as members of the afrotherian subclade Paenungulata, which also includes Proboscidea, Hyracoidea and Sirenia. An African origin for the group is supported by their status as paenungulates, their early appearance in the fossil record of Africa, and the basal phylogenetic position of the Moroccan embrithopod *Stylolophus* with respect to other known embrithopod taxa. Despite the strong likelihood that embrithopods originated in Africa, they succeeded in colonizing the insular terrane of Balkanatolia during the early Paleogene, presumably via dispersal across Tethys. Prior to its colonization by Asian mammals in the Bartonian, embrithopods were the only large mammalian herbivores known to occur on Balkanatolia. However, the timing of embrithopod colonization of Balkanatolia and their early evolution on this insular terrane have remained enigmatic.

The newly discovered locality of Camiliyayla mezra in the southern Çiçekdaği Basin has yielded fossils documenting two sympatric taxa of embrithopods that appear to rank among the oldest embrithopods known from Balkanatolia. Biostratigraphic and geochronologic age constraints on the new site indicate that it is older than middle Lutetian; ongoing research aims to constrain the age of the site further. Neither of the embrithopods from Camiliyayla mezra belongs to the most common early Paleogene Turkish embrithopod, *Palaeoamasia*. Rather, the larger taxon can be referred to the poorly documented genus *Hypsamasia*, while the smaller taxon appears to be a primitive species of *Crivadiatherium*, otherwise known only from later Eocene strata of Romania.

The embrithopod fauna of Camiliyayla mezra indicates that this clade experienced a modest adaptive radiation after successfully colonizing Balkanatolia. The Balkanatolian record of embrithopod evolution contrasts with the evolutionary history of this clade in its native Africa, where sympatric taxa of embrithopods have never been documented. In situ diversification of embrithopods was facilitated by the endemic and unbalanced character of Balkanatolian faunas, particularly the absence of other large-bodied herbivores like proboscideans, which were diverse and abundant in the early Paleogene of Africa.

**Funding Sources** This research has been supported by NSF 2141115 to KCB and ERC 101043268 to AL.

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

## *TYRANNOSAURUS* BITE MARKS ON A CERATOPSID FRILL FROM THE LATE CRETACEOUS HELL CREEK FORMATION OF NORTH DAKOTA, USA

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Although bite marks on non-avian dinosaur bones have rarely been described in scientific literature, they provide valuable evidence of real-world ecological interactions between once-living organisms. Here we describe a partial ceratopsid squamosal containing multiple punctures, bite-and-drag, and drag marks across its dorsal surface, at least some of which are attributable to *Tyrannosaurus*. The isolated bone was excavated near Marmarth, North Dakota, from mudstone of the Maastrichtian Hell Creek Formation. It is heavily damaged, with the lateral and caudal margins entirely missing and only the anterior third, from the jugal suture to the medial margin, remaining.

Three large punctures lie along the bone's damaged lateral side. One is complete, 40 mm wide, 22 mm deep and does not completely penetrate the bone. The others penetrate the bone and appear to be similar in size and shape, but they are incomplete. The edges of these large punctures are sharp and show no signs of bone growth. A 5 mm-wide, 34 mm-long bite-and-drag mark with a jagged border lies near the complete puncture.

An 8 mm-wide bite-and-drag mark extends 43 mm to the medial margin, where it creates a 10 mm-wide notch in the edge of the bone. It has raised, rugose edges. The ventral bone surface inferior to this gouge is slightly thickened at the medial margin, forming a bump.

A group of much smaller subparallel bite-and-drag and drag marks crosses the anterior portion of the bone. Two curved score marks extend 120 mm anteriorly from small triangular punctures less than 5 mm wide. Several other possible score marks without punctures are also present. These marks are all approximately 2 mm wide and have raised surfaces along at least part of their lengths.

The various marks with rugose edges and raised surfaces suggest that this individual survived some trauma to its frill caused by one or more unknown attackers. We interpret the other marks with sharp edges and the major damage to the bone to be the result of biting by *Tyrannosaurus*, the only large carnivore known from the Hell Creek Formation. The approximate size and spacing of the large punctures are comparable to the size and spacing of *Tyrannosaurus* maxillary teeth. The presence of *Tyrannosaurus* bite marks on a ceratopsian frill likely has little to do with feeding on the frill itself but is consistent with the hypothesis that the carnivore manipulated ceratopsian skulls during the postmortem dismembering of their carcasses.

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Technical Session 12: Methods & Paleohistology (Friday, October 20, 2023, 8:00 AM)

## BONE CONCENTRATIONS UNDER ISOLATED TREES AS A MODEL FOR TIME-AVERAGED, SPECIES-RICH FOSSIL ASSEMBLAGES

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Taphonomic processes that generate concentrations of skeletal remains are responsible for a significant proportion of the fossil record and also important in reconstructions of human versus non-human behavior in archaeological sites. Here we report on spatially focused bone assemblages associated with isolated trees in the modern-day savanna habitat of Amboseli National Park, Kenya. Controlled sampling of areas under 14 *Acacia tortilis* trees resulted in 2220 identifiable bones and a minimum of 196 individuals representing a wide range of body sizes and species in five vertebrate classes. These include 15 mammalian genera, with brown hare (*Lepus capensis*) and Thomson's gazelle (*Eudorcas thomsonii*) most common (8/14 and 7/14 of the tree assemblages, respectively). Birds are more diverse than mammals (29 species), but their remains less abundant. Trees are 10-1000m apart and more isolated ones tend to have more bones. Observed or inferred taphonomic processes responsible for tree concentrations involve the activities of predatory birds and mammals, including humans. Although some deaths likely occurred in direct association with the trees, most remains were transported there by faunivores (meat and bone consumers) attracted to shade, protective cover, and/or roosting sites. Terrestrial mammals and birds dominate, but fish occur at 6/14 trees and were transported 1 km or more from the nearest water source. In addition to predator modification (e.g., breakage patterns, digestive dissolution, toothmarks), taphonomic features include trampling breakage, insect and root damage, and long-term weathering (i.e., years to decades) on organic-rich substrates. Results show that typical taphonomic signatures of bone assemblages under Amboseli trees include: 1) relatively high spatial density (.31 bones/m$^2$) compared with surrounding land surface bone assemblage (.002 bones/m$^2$), 2) variable but generally high diversity (~6-24 species) per tree, with greater representation of small body sizes, 3) bias toward mammalian appendicular remains, contrasting with bias toward cranial and axial remains for fish and reptiles, 4) high frequency of juvenile to sub-adult large mammals, 5) weathering stages lower than in the land surface assemblage. Isolated trees as attractors for biologically-generated bone concentrations provide a conceptual model that may help to explain spatially focused, high-diversity assemblages that occur throughout much of the land vertebrate fossil record.

**Funding Sources** National Geographic Grant #1508 Amboseli Support (1975 – 1985), Smithsonian Institution Short-term Visitor Grant

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**FIRST OCCURRENCE OF THE EARLY PALEOCENE MAMMAL HEMITHLAEUS IN THE DENVER BASIN, COLORADO, WITH IMPLICATIONS FOR TOOTH REPLACEMENT IN ARCHAIC UNGULATES**

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Archaic ungulates were among the most speciose and ecologically diverse mammals in the early aftermath of the Cretaceous-Paleogene (K-Pg) mass extinction. The Puercan North American Land Mammal 'age' (NALMA) captures the first ca. 1 million years (Ma) of the Paleocene and is characterized mostly by archaic ungulates present in the San Juan Basin of New Mexico. Elsewhere in the Western Interior of North America, Puercan mammals are primarily known from isolated teeth and jaw fragments. Recently, abundant skulls with associated upper and lower dentitions of archaic ungulates have been discovered at Corral Bluffs, an exposure of earliest Paleocene portions of the Denver Formation just east of Colorado Springs, Colorado, providing a new window into the earliest evolution of archaic ungulates. In this study, we describe the upper and lower dentition of an archaic ungulate (DMNH EPV.141855) from ca. 600 thousand years after the K-Pg boundary (Puercan 2 NALMA; 101.5 m above the pollen-defined K-Pg boundaries; GPTS [2012] age model = 65.40 Ma) at Corral Bluffs. The specimen exhibits an erupting left P2, deciduous (d)P/p3–4, M/m1–2, and erupting right M/m3. The dP/p3 resemble those of the adult dentition, whereas dP/p4 are molariform and resemble M/m1. We assign DMNH EPV.141855 to the periptychine periptychid species *Hemithlaeus kowalevskianus* based primarily on: (1) protocone apex shifted buccally with prominent lingual slope, (2) reduced hypocone equal in size to pericone; both at the same mesiodistal line lingual to the protocone apex, (3) paraconid small and level with the height of talonid cusps, situated

near base of protoconid, (4) metaconid shifted distobuccally and situated near prominent protoconid, and (5) within size range of other *H. kowalevskianus* specimens (e.g., m2 L = 4.93 mm). DMNH EPV.141855 thus represents the first occurrence of *H. kowalevskianus* from the Denver Basin. Further, the preservation of both the dP/p3–4 and the unerupted adult premolars in the crypt of the maxillae and dentaries (confirmed via digital preparation of µCT data) represents one of the earliest examples of tooth replacement patterns in Paleocene mammals, and one of the only periptychid genera for which aspects of the dental eruption sequence is known. Future study will compare tooth replacement patterns of *H. kowalevskianus* to those of other archaic ungulates and eutherians, potentially illuminating the evolution of dental eruption sequence among early placental mammals.

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Technical Session 1: Sauropod & Ornithischian Dinosaurs (Wednesday, October 18, 2023, 8:00 AM)

**A NEW KRITOSAURIN HADROSAURID (DINOSAURIA: ORNITHOPODA) FROM THE LATE CAMPANIAN WILLIAMS FORK FORMATION OF COLORADO**

Bender, Emerald R.[1], Gates, Terry A.[1], Johnson, Elizabeth[2], Zanno, Lindsay E.[3]

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The past two decades of research have revealed an exceptional diversity of hadrosaurids in the Late Cretaceous Western Interior Basin of North America, and ongoing discoveries continue to refine the biogeographic and phylogenetic history of this clade. We present the cranial osteology of the first uniquely diagnosable hadrosaurid remains from the late Campanian Williams Fork Formation of Colorado. The new taxon is represented by CNFM-001, a specimen comprising a nearly-complete skull, partial postcranial skeleton, and skin impressions. CNFM-001 is referable to Kritosaurini based on the concave ventral margin of the jugal, triangular rostrolateral projection of the frontal between the postorbital and prefrontal, and subrectangular dorsal border of the infratemporal fenestra. It is most prominently differentiable from other kritosaurins by its unique nasal morphology: the nasal crest is flattened, rostrally elongate, transversely broad, and lies below the level of the orbits. This contrasts with the tall, arcuate, and transversely narrow nasals of *Gryposaurus* and the rostrocaudally abbreviated arch of *Rhinorex*. The novel taxon is further distinguished by dorsoventrally shallow maxillae, a rugose proximal nasal crest, a straight, transversely oriented frontonasal suture, and ventrolaterally splayed exoccipital condyloids, among other characters.

The addition of CNFM-001 to the phylogeny of hadrosaurs provides continuity to the evolutionary history of Kritosaurini, constraining the sequence of character acquisition and refining diagnoses in close relatives. For example, the dramatic rostrocaudal thickening of the dorsal margin of the paroccipital processes, formerly thought to be an autapomorphy of *Gryposaurus*, is shared with the new taxon. CNFM-001 also increases the known diversity of nasal crest ornaments in Kritosaurini, which are generally more morphologically conserved than the ornamentation observed in other clades such as Brachylophosaurini and Saurolophini. CNFM-001 consistently diverges after *Kritosaurus* and before *Rhinorex* and *Gryposaurus* in isolated most-parsimonious trees and Bayesian maximum clade credibility trees, but Kritosaurini remains unresolved in majority-rule consensus topologies. Therefore, further development of hadrosaur phylogeny is required to confidently infer character history in this clade.

**Funding Sources** This project was funded by the Paleontological Society Student Research Award

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Technical Session 7: Birds (Thursday, October 19, 2023, 8:00 AM)

**NEW DATA ON LATE CRETACEOUS STEM BIRDS CLARIFIES THE PLESIOMORPHIC CONDITION OF THE NEORNITHINE POSTCRANIAL SKELETON**

Benito, Juan, Steell, Elizabeth, Widrig, Klara E., Field, Daniel J.

Department of Earth Sciences, University of Cambridge, Cambridge, Cambridgeshire, United Kingdom

Neornithes (the bird crown group) originated during the Late Cretaceous, yet their fossil record predating the end-Cretaceous Mass extinction is extremely

scarce. A large number of fragmentary Late Cretaceous avian remains have been suggested to exhibit affinities to Galloanserae (waterfowl + landfowl), and the only two well-supported Cretaceous neornithines are thought to belong to this clade. Similarly, total group Anseriformes (waterfowl) are amongst the most diverse and abundant early Cenozoic neornithines. A neognathous, and in particular, a galloanseran-like palate configuration has recently been interpreted as plesiomorphic for Neornithes, casting doubt on the purported galloanseran affinities of several Cenozoic neornithine lineages. However, the plesiomorphic condition of numerous additional aspects of the neornithine postcranial skeleton remain uncertain. Here we re-evaluate a crownward stem bird specimen from North America, and suggest that several aspects of its postcranial anatomy, particularly the morphology of the scapula, coracoid and carpometacarpus, are remarkably similar to those of early Cenozoic Anseriformes such as *Presbyornis*. However, these 'galloanseran' features are combined with hindlimb morphologies shared with stem palaeognaths, raising the intriguing possibility that numerous aspects of the postcranial anatomy of early total-group Anseriformes could be plesiomorphic for Neornithes. Combined with recent insights on the ancestral crown bird palate, these results may force reconsideration of the purported galloanseran and neornithine affinities of several Cretaceous and early Cenozoic fossil birds, with potential implications for assessing the age of the deepest divergences among Neornithes in the Cretaceous. Furthermore, the postcranial similarities of crownward stem birds and earliest Cenozoic Anseriformes may hint at the ecology of the earliest crown birds and their survivorship through the end-Cretaceous mass extinction.

**Funding Sources** This research was supported by the UKRI grant MR/S032177/1 awarded to D.J.F. and by funds provided by the Systematic Association and The Geologists' Association.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**EFFECTS OF SNAKE DIGESTION ON SMALL MAMMAL SKELETONS**

Bennett, Todd B.[1], Patterson, David B.[2], Mead, Alfred[1]

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Small mammals are a uniquely important group for understanding paleoecology due to their restricted habitat and sensitivity to changing environments. While owl pellet analysis has been used to document taphonomic signatures on small mammal fossils, few studies have focused on the signatures of other animal clades, although a small number have examined digestive damage due to mammals and reptiles. Research presented here examines digestive modification by 17 extant species of snakes in comparison to modern owls. This study lays out a systematic approach for recovering rodent remains from snake fecal material as well as detecting and characterizing tooth and bone modification. Rodent teeth ($n \geq 50$) from snake fecal remains show extreme modification similar to damage from carnivorous mammals. The extreme modification is markedly different from that on remains collected from owl pellets ($n \geq 50$) which show very light modification. An understanding of the different taphonomic signatures can be used to infer the concentrating agents of the recently documented rodent community at Clark Quarry, a Pleistocene fossil locality in Brunswick, Georgia, U.S.

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**SENSORY ORGANS AND PALAEOBIOLOGY OF CYNODONTS**

Benoit, Julien

Evolutionary Studies Institute, University of the Witwatersrand, Johannesburg-Braamfontein, Gauteng, South Africa

All modern mammals are descended from the paraphyletic non-mammaliaform cynodonts. It has long been assumed that the biology of these mammalian ancestors was essentially reptilian-like, including simple behavior, low metabolism, small brain, poor sense organs, and unrefined motor coordination. With recent exploration of Permian-Triassic exposures and CT scanning becoming more commonplace in paleontology labs, new data on early cynodonts has since helped refine this picture and update this view. Recent research has brought new evidence that paleoneurological and behavioral traits previously considered typically mammalian, such as whiskers, nocturnality, enhanced olfaction, lactation, gregariousness and enlarged cerebral hemispheres actually evolved before the very origin of clade Mammaliaformes. Adaptations to nocturnality and small body size in non-mammaliaform cynodonts triggered a neurosensory revolution that started before the origin of mammaliaforms, possibly in correlation with the Carnian Pluvial Episode and the evolution of endothermy as the archosaurs were becoming the dominant taxa over terrestrial ecosystems.

**Funding Sources** The National Research Foundation and its African Origins Platform programme (AOP210218587003, Grant No: 136505).

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Technical Session 21: Squamates (Saturday, October 21, 2023, 1:45 PM)

## PARVIRAPTOR-LIKE SQUAMATE FROM THE MIDDLE JURASSIC OF SCOTLAND

Benson, Roger B.[1], Walsh, Stig[2], Fernandez, Vincent[3], Griffiths, Elizabeth[4], Head, Jason[5], Evans, Susan[6]

[1]Department of Vertebrate Paleontology, American Museum of Natural History, New York, New York, United States, [2]National Museums of Scotland, Edinburgh, United Kingdom, [3]European Synchrotron Radiation Facility, Grenoble, France, [4]University of Oxford, Oxford, United Kingdom, [5]University of Cambridge, Cambridge, United Kingdom, [6]University College London, London, United Kingdom

Squamates (lizards and snakes) comprise approximately 10,000 living species and diverged from their closest living relative, *Sphenodon*, during the early Triassic. However, confident records of crown- or near-crown squamates are not known prior to the Middle Jurassic. Jurassic and Early Cretaceous squamate assemblages include taxa that have been assigned to the stem lineages of most major living groups, including the genus *Parviraptor* and closely-related genera from North America and Europe. These taxa have been identified at various times as being anguimorphs, gekkonomorphs, members of a 'scincomorph'-anguimorph group, and more recently as stem-snakes. Specimens of these taxa so far are relatively incomplete, have been incompletely-described, or have been identified as potentially being chimaeric associations of multiple taxa, leading to difficulties evaluating these phylogenetic hypotheses.

We report a new specimen of a *Parviraptor*-like squamate from the Middle Jurassic (Bathonian) Kimaluag Formation of Isle of Skye, Scotland. The specimen comprises a partial cranium, right mandible, many ribs and vertebrae, and portions of the pectoral and pelvic limbs. The morphology of this new specimen, revealed using synchrotron tomography, confirms the that cranial bones of *Parviraptor estesi*, from the Early Cretaceous of the UK, do not represent a chimaeric association, and provides substantial new information on the anatomy of these taxa, providing sufficient data for 3D skull reconstruction and information on body proportions. The specimen shows varanid-like gross cranial anatomy, with snake-like features restricted primarily to the teeth and tooth-bearing elements, and 'lizard'-like body proportions with a short trunk and well-developed limbs and limb girdles. Many anatomical details differ from both snakes and varanids and include a mosaic of primitive and derived features within Squamata. Bayesian phylogenetic analysis using a fossilize-birth-death tree prior and molecular backbone constraint for different matrices provides potential support for affinities of *Parviraptor*-like squamates as either near-crown stem-squamates or stem-snakes, with most of the support for a relationship with snakes coming from aspects of dental or mandibular anatomy. These specimens therefore provide potential evidence for an early-diverging squamate group that independently evolved snake- or anguimorph-like features, probably related to dietary ecology.

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Technical Session 12: Methods & Paleohistology (Friday, October 20, 2023, 8:00 AM)

## UNEXPECTED DISCREPANCY BETWEEN BONE MICROANATOMY AND PRESUMED LIFESTYLE REVEALED IN CARBONIFEROUS TETRAPODS

Bijl, Sifra[1], Tafforeau, Paul[2], Ahlberg, Per[1], Clement, Alice[3], Bishop, Peter[4], Clack, Jenny[5], Sanchez, Sophie[1]

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University, Cambridge, Massachusetts, United States, [5]University Museum of Zoology, Cambridge, United Kingdom

The terrestrialisation of vertebrates is a major evolutionary event that involved drastic changes in the limb bones. It has been an area of great interest in the paleontological community. However, little focus has been put on the patterns of ossification of these bones, mostly due to the scarcity of the fossil material. This study aims to map in detail the diversity of bone patterns in the humeri of a wide variety of early tetrapods from the Carboniferous, based on a non-destructive method: propagation phase-contrast synchrotron microtomography. We looked at the internal bone architecture of the following Carboniferous genera: *Baphetes*, *Pederpes*, *Ossinodus* and *Crassigyrinus*. We investigated their ossification patterns and bone microanatomy. Unexpectedly, our results reveal that they all retain a very spongy microanatomy, regardless of their varying lifestyles (from aquatic to terrestrial). They all have an unossified anterior margin where muscles are expected to connect and play a major role, even in terrestrial locomotion. This discrepancy between bone compactness, ossification pattern and lifestyle suggests that cartilaginous entheses probably played a function in the adaptation of Carboniferous tetrapods to land. This further indicates that a shift in microanatomy towards a more tubular long-bone structure in terrestrial locomotion is probably a more derived feature than expected.

**Funding Sources** Vetenskaps Rådet 2019-04595 to Sophie Sanchez. Applied to Uppsala's Håkansson travel scholarship as well as the Gertrud Thelin travel scholarships, decision pending

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Technical Session 2: Early Mammals & Carnivora (Wednesday, October 18, 2023, 8:00 AM)

### NEW METATHERIANS FROM THE PALEOCENE-EOCENE OF TROPICAL SOUTH AMERICA

Bloch, Jonathan I.[1], Suarez, Catalina[2], Rincon, Aldo[3], Vallejo-Pareja, Maria C.[1], Head, Jason[4], Hastings, Alexander K.[5], Cadena, Edwin A.[6], Jaramillo, Carlos[7]

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While metatherian mammals are an important component of tropical ecosystems in South America today, their Paleogene fossil record is largely restricted to mid-to-high latitudes, greatly limiting our understanding of their history during the first half of the Cenozoic. Here we describe metatherians from two stratigraphically distinct fossil vertebrate localities separated by 443 meters in the Bogotá Formation outcropping along Mochuelo Creek in southern Bogotá, Colombia. The Bogotá Formation consists of fluvial sandstones and mudstones with well-developed paleosols, previously interpreted as a meandering to braided fluvial depositional system, and vertebrate fossils are concentrated in conglomeratic channel-lags. An age model based on recently published Zircon U-Pb dates for a generalized section suggests a mid-to-late Paleocene (59 Ma) age for Locality 2, and an early Eocene (55.6 Ma) age for Locality 1 (~100 meters above the Paleocene-Eocene Thermal Maximum, PETM).

Only a few diagnostic fossils have been recovered from the Paleocene Locality 2, with the most significant find a left maxilla P3-M4 of a stem metatherian that shares several characteristics found in pucadelphid (e.g., *Pucadelphys* and *Andinodelphys*) and mayulestid (e.g., *Mayulestes*) “ameridelphians” otherwise known from the early Paleocene of Tiupampa, Bolivia. Several additional isolated and fragmentary teeth from Locality 2 suggest the presence of at least two additional metatherian taxa. A relatively complete metatherian femur with similarities to more arboreal marsupials (e.g., size and shape of greater and lesser trochanters, distal condyle shape and height) was also recovered. Collecting in the Eocene Locality 1 has yielded a larger sample of diagnostic metatherians, including partial upper and lower dentitions and numerous isolated teeth that have clear affinities with taxa found from the early Eocene of Itaboraí, Brazil. These include several new taxa referred to the family Protodidelphidae, at least one derorhynchid, a possible microbiothere (or polydolopimorphian) similar to *Mirandatherium*, and several other small “ameridelphians.” This well-dated section with terrestrial mammal faunas spanning the late Paleocene to early Eocene is unique in the tropics and allows for correlation to sections at mid-to-high latitudes in South America and a better understanding of faunal dynamics across the PETM hyperthermal.

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Technical Session 16: Theropods - I (Saturday, October 21, 2023, 8:00 AM)

**SIZE VARIATION, INCREASED BODY MASS ESTIMATES, AND POTENTIAL SEXUAL DIMORPHISM IN CAMPANIAN THEROPOD *TROODON FORMOSUS***

Boekenheide, Harris R.[1], Varricchio, David J.[1], Scannella, John[2], Carrano, Matthew T.[3]

[1]Earth Sciences, Montana State University, Bozeman, Montana, United States, [2]Paleontology, Museum of the Rockies, Bozeman, Montana, United States, [3]Paleobiology, Smithsonian Institution, Washington, District of Columbia, United States

The Late Cretaceous troodontid theropod, *Troodon formosus*, has long been known to inhabit North America. However, the fragmentary nature of the bones that have been uncovered thus far means there is still much about the species that evades our understanding. The use of new bone correlation and body mass estimation methodologies on femora and tibiae attributed to *Troodon formosus* revealed that a considerable number of bones possessed circumferences indicative of body masses up to nearly 50% greater than those suggested by previous estimates. By measuring the lines of arrested growth and annuli visible in histologic thin section, we tracked the annual growth rates of several individuals. While juveniles appeared to grow at fairly homogenous rates, the growth strategies of adult individuals were highly variable, with adult individuals developing an external fundamental system either around 40-45 kg or 67-73 kg. Though potentially the result of harsh environmental conditions leading to high degrees of individual variation, the consistency in size variation may favor sexual size dimorphism in *Troodon*.

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Technical Session 20: Marine Mammals & Bats (Saturday, October 21, 2023, 1:45 PM)

**EXTREME DIVERSITY OF SPEAR-TOOTHED, WAIPATIID-GRADE DOLPHINS (CETACEA: ODONTOCETI) FROM THE OLIGOCENE ASHLEY AND CHANDLER BRIDGE FORMATIONS OF SOUTH CAROLINA, USA**

Boessenecker, Robert[1], Geisler, Jonathan H.[2]

[1]Mace Brown Museum of Natural History, College of Charleston, Charleston, South Carolina, United States, [2]Department of Anatomy, New York Institute of Technology, Old Westbury, New York, United States

Waipatiidae are a clade or grade of small-bodied (2-2.5 m long) heterodont, polydont, mesorostrine archaic dolphins (stem Odontoceti) further characterized by intermediate telescoping, large temporal fossae, narrow dorsal parietal exposure, and resembling Squalodontidae. Fossiliferous beds of the lower Oligocene Ashley Formation (AF; 28-30 Ma, Rupelian) and upper Oligocene Chandler Bridge Formation (CBF; 24.5-23.5 Ma, Chattian) from Charleston, South Carolina have produced an unusually diverse assemblage of *Waipatia*-like odontocetes, including at least eight morphotypes. The only named waipatiid-grade dolphin from South Carolina is *Ediscetus osbornei*, (BZW:199mm, AF) with an unusual degree of cranial telescoping, attenuated rostrum, and procumbent incisors. One or two additional species of *Ediscetus* are represented by several skulls (CCNHM 208, 210; ChM PV 4755; BZW: 189-194 mm; AF) with narrower intertemporal constriction and greater parietal exposure. A small waipatiid (BZW: 161 mm) with small teeth is represented by four skulls (CCNHM 2609, 4269, ChM PV 4824, 7679; AF). The most completely preserved form is known from skulls and a skeleton (CCNHM 172, ChM PV 4961; BZW: 192mm; CBF) with longirostry and procumbent incisors and a well-preserved postcranial skeleton. Two odontocetes possibly assignable to *Waipatia* include a gracile form with a triangular nasofrontal suture and hemispherical promontorium represented by three skulls (CCNHM 567, 1074, BZW: 219-232 mm; CBF) and a robust form with a transverse nasofrontal suture and wedge-shaped promontorium represented by three skulls (CCNHM 559, 1078, ChM PV 8710; est. BZW: 230 mm; CBF). Large crania (BZW: 230-270 mm; CBF) with narrow facial regions and a dorsoventrally deep braincase, overlapping cheek teeth, and periotic with long anterior process represent one or two morphotypes; a robust form (CCNHM 558) with bilateral parietal triangles and a gracile form (CCNHM 563, 1847; ChM PV 4753, 4878) with transverse parietal band. Phylogenetic analysis recovers some of these taxa as stem odontocetes intermingling with agorophiid-grade and squalodontid-grade taxa. At least four waipatiid-

grade dolphins are present in the Ashley Fm. and five are present in the overlying Chandler Bridge Fm. These eight waipatiids, along with 25 other Oligocene odontocetes from these strata, highlight an explosive radiation of Odontoceti shortly after its divergence from Mysticeti.

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Education & Outreach Poster Session (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**THE SKULL CHALLENGE: AN OUTREACH ACTIVITY TEACHING VISITORS ABOUT ANATOMY AND HOW PALEONTOLOGISTS IDENTIFY AND INTERPRET THE BONES THEY FIND**

Boessenecker, Sarah[1], Boessenecker, Robert[2]

[1]Collections, Mace Brown Museum of Natural History, North Charleston, South Carolina, United States, [2]Geology, College of Charleston, Charleston, South Carolina, United States

Outreach is an important part of museum work and can help visitors learn more than they can by simply reading a museum panel and can also be beneficial by extending the museum outside of its walls, and allowing those that may not be able to visit and learn a chance to share with the museum. By using outreach, ideas can be taught in a different way than what static museum exhibits can offer by giving a hands-on interactive experience. The 'Skull Challenge Game' was created as an interactive learning experience for all ages and is used to help explain how animals look very different externally v. their skeleton. Osteological specimens such as skulls from various mammals (*Canis*, *Lynx*, *Procyon*, *Tayassu*, *Tursiops*, *Ursus*), reptiles (*Alligator*), shark jaws (*Carcharhinus*, *Ginglymostoma*, *Rhinobatos*), fossil teeth (*Mammuthus*, *Mammut*), and 3D prints of fossil skulls are used. Pictures of the animals in question were affixed to wooden blocks. The skulls, teeth, and jaws are set out and visitors are asked to match the picture to the specimens on the table by placing the matching block adjacent to the specimen. The dentition in the skulls or shark jaws can show what the animal may have been feeding on, and structures like tusks or antlers can help determine if they were for social behaviors or used for defense against predators. Three separate shark jaws are used to explain different feeding styles used by each shark (piscivorous, durophagous, and an intermediate generalist dentition). Using osteological specimens as well as 3D printed and real fossils, visitors are asked what they have learned about the modern skulls of living animals they can see to transfer that knowledge to the fossils and see what they think the animal may have looked like in life, or their feeding habits. This is followed up with asking *why* they feel something is this way, to help them develop critical thinking skills. This helps to explain how paleontologists use a wide range of evidence to understand what fossils found of an animal would look like in life. Children tend to do far better at this game than adults, as they tend to be less set in their understanding of the world around them and this often helps. Children may also be more familiar with basic zoology and many adults are so far separated from their education they have forgotten much of their K-12 zoological education. It is recommended that osteological specimens of local wildlife are used, as they may be most familiar to the audience.

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Colbert Poster Prize Session

**BIOMECHANICAL ANALYSIS OF *SMILODON* FORELIMBS REVEALS UNIQUE ADAPTATIONS FOR PREY ACQUSITION AND PROCESSING**

Bogner, Emily[1], Meachen, Julie[2], Tseng, Z. Jack[1]

[1]Integrative Biology, University of California Berkeley, Berkeley, California, United States, [2]Des Moines University, Des Moines, Iowa, United States

Saber-toothed cats (*Smilidon fatalis*) are well known for their charismatic canine teeth; however, their axially elongated and laterally compressed sabers were more fragile and prone to breaking than the conical canines of living felids. Previous biomechanical simulations suggest that *S. fatalis* crania had weak extrinsic loading strength when compared to lions (*Panthera leo*), which raises the question of whether the strength of *S. fatalis*' arms compensated for this weakness when holding down prey. We leveraged heterogeneous finite element (FE) models generated with species-specific material properties to assess the strength of *S. fatalis*' forelimbs in prey-holding posture. Results indicate *S. fatalis* had the strongest overall forearm strength compared to pantherines, exceeding that of lion (*P. leo*), leopard (*P. pardus*), jaguar (*P. onca*), and was most similar to tiger (*P. tigris*). Interpreted in light of recent findings on mandibular strength using FE data, *S. fatalis* had a weaker skull than some pantherines, but may have compensated with both stronger mandibular and arm strength to stabilize its prey and protect its canines at high gape angles. This study represents the first paleobiological study to integrate FE data from both cranial and postcranial elements and provides valuable insight into the biomechanics and behavior of *S. fatalis*, specifically in terms of its unique adaptation to prey acquisition and processing. These findings are consistent with the inference that sabertooth evolution involved widespread modification and coordination of musculoskeletal performance in increasingly specialized forms.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**A COLOSTIED FROM THE EARLY PENNSYLVANIAN OF ARKANSAS**

Bohus, Caleb P.[1], Pardo, Jason[2]

[1]Illinois State Geological Survey, Chicago, Illinois, United States, [2]Field Museum of Natural History, Chicago, Illinois, United States

Colosteids are a distinct fauna typical of Late Mississippian and Early Pennsylvanian tetrapod assemblages. Within North America, several colosteids are known, notably, *Colosteus scutellatus* from the Late Westphalian of Ohio, *Greererepton burkemorani* from the Late Serpukhovian of West Virginia, and *Deltaherpeton hiemstrae* from the Late Viséan of Iowa. Abundant but insufficiently described colosteid material has also been reported from numerous localities and horizons within the Illinois Basin, including the Late Serpukhovian Goreville/Buncombe locality of Southern Illinois and the Buffalo Wallow Formation of Western Kentucky, and the Visèan St. Louis Limestone of Missouri. We here report the first Pennsylvanian colosteid from the Illinois Basin, a partial skull from the Early Pennsylvanian near Fayetteville, Arkansas, in the extreme Southwest portion of the Illinois Basin. The specimen was acquired by the FMNH through a purchase from a local miner in the late 1800s, during the initial development of the FMNH collections. Mines in the Fayetteville area typically target the Baldwin Coal, which is near the top of the Woosley Member of the Bloyd Formation, dated within the Early Pennsylvanian Period, Morrowan Series, equivalent to the Bashkirian. Using X-ray computed tomography we here describe characters that lead us to identify PR 695 as a colosteid, including a distinct relationship between the stapes, quadrate, and parasphenoid, and coarse radiating dermal sculpture typical of colosteids. Although the Fayetteville colosteid is represented by only a small portion of the skull, it appears to represent a relatively flattened animal. This is similar to the state seen in *Greererpeton* and *Deltaherpeton* and distinct from the deeper-skulled Goreville colosteid, suggesting some anatomical and functional diversity within the colosteids of the Illinois Basin. This new record also establishes the persistence of the family throughout the Mississippian-Pennsylvanian boundary within the Illinois Basin, consistent with the pattern observed in the Appalachia. This new record of a colosteid from Arkansas adds to an otherwise sparse Carboniferous vertebrate fauna from the state, otherwise limited to a fragmentary temnospondyl and possibly the embolomere *Eobaphetes kansensis*.

**Funding Sources** Jingmai O'Connor for providing CT scans and use of resources in their lab.

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Technical Session 19: Theropods - II (Saturday, October 21, 2023, 1:45 PM)

**TALES OF STRONG JAWS, ENIGMATIC PASTS, AND TINY FORELIMBS: A TEMPORAL-SPATIAL LOOK INTO FIVE CLADES CONTAINING CARNIVOROUS MEGATHEROPODS AND THEIR DIVERSITY ACROSS THE LATTER MESOZOIC ERA**

Boisvert, Colin[1], Perkins, Jack[2], Curtice, Brian[3]

[1]Department of Geological Sciences, Brigham Young University, Provo, Utah, United States, [2]Unaffiliated, Carlton, Victoria, Australia, [3]Arizona Museum of Natural History, Mesa, Arizona, United States

Megatheropods represent theropods over nine meters in length. Temporal and spatial diversity patterns among valid species of five clades containing megatheropods, Abelisauroidea, Megalosauroidea, Allosauroidea, Megaraptora, and Tyrannosauroidea, were examined, with special consideration given to overlapping between clades. Valid species within these clades were given a single temporal value, a landmass for its occurrence, and paleolatitude/longitude coordinates derived from PaleoDB.

Plotting species count, via R, across all landmasses by clade revealed the most concentrated clade by landmasses were tyrannosauroids. The most diverse clade currently by number of landmasses inhabited were the abelisauroids. Landmasses without existing valid species from these five clades, such as

Antarctica, were not included.
Temporal diversity by species counts across five time bins (Early, Middle, Late Jurassic; Early, Late Cretaceous periods) for the five clades revealed abelisauroids, tyrannosauroids, and megaraptorans demonstrated delayed adaptive radiation above five species till the Late Cretaceous coupled with respective explosions in species count. This coincides with the decline of megalosauroid and allosauroid species in the Late Cretaceous. Megalosauroids show a bimodally peaked temporal distribution with the highest species count in the Middle Jurassic and Early Cretaceous. Allosauroids have a more right-shifted, unimodally-peaked distribution, with the highest diversity in the Early Cretaceous. An interesting trend is the low diversity of several clades in the Middle Jurassic compared to the high diversity of megalosauroids.

The Overlap plot looked for occurrences where at least one species from two clades were simultaneously present on the same continent. Nineteen temporal overlaps were present, with two overlaps occurring on multiple continents. Although a few outliers in the Northern and Southern Hemisphere exist, an overall trend of early Northern Overlap followed by later Southern Overlap emerged. Europe was treated as an ecotone where taxa from both hemispheres intermixed. This trend may relate to niche partitioning and the emergence of particular predatory clades. Nevertheless, several points remain, such as a necessity to discover more Jurassic Southern Hemisphere localities, a need to generally study more sites in the Southern Hemisphere to fill in gaps, and clades such as megaraptorans, allosauroids, and megalosauroids require further research.

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Virtual Posters

**NEW SPECIMENS OF PLIO-PLEISTOCENE ODOBENINES FROM THE NORTH SEA GIVE NEW INSIGHT ON THE PAST DIVERSITY OF THE GENUS *ONTOCETUS***

Boisville, Mathieu[1], Chatar, Narimane[2], Kohno, Naoki[3]

[1]Earth Historical Analysis, Tsukuba Daigaku Daigakuin Seimei Kankyo Kagaku Kenkyuka, Tsukuba, Ibaraki, Japan, [2]Department of Geology, University of Liège, Diversity Dynamics Lab, Liège, Belgium, [3]Department of Geology and Paleontology, National Museum of Nature and Science, Tsukuba, Ibaraki, Japan

The walrus (*Odobenus rosmarus*) is one of the most iconic mammals of the Arctic, significantly differing from all other pinnipeds by its size and prominent tusks. The walrus is the only extant member of the family Odobenidae although this family had one of the highest diversities in the fossil record within pinnipeds. Phylogenetically, the extant walrus lies in the tribe Odobenini with fossil genera such as *Protodobenus*, *Ontocetus*, and *Valenictus*. Odobenids are characterized not only by a significant development of the upper canines and premolariform lower canines, but also an absence of enamel. Odobenines first originated in the North Pacific but some taxa then dispersed in the North Atlantic during the Early Pliocene. Over the past 17 million years, a succession of evolutionary grades have been identified from the earlier enaliarctine taxa to the extant walrus.

*Ontocetus* is the most well-known fossil odobenine thanks to its worldwide distribution. Its oldest occurrence is in the Lower Pliocene of Japan, but it quickly spread out into the North Atlantic Ocean during the Pliocene being notably found in England, Belgium, the Netherlands, the east coast of the United States and even in Morocco. Historically, five genera and eight species of Plio-Pleistocene *Ontocetus*-like walruses have been described, but with species defined based on different skeletal elements across taxa. However, based on the tusks, all the specimens found in the North Sea have been found to integrate the ontogenetic and sexual variation of *Ontocetus emmonsi* from the U.S. East Coast. Recent studies using morphometric geometrics have highlighted how other skeletal elements could be used as a proxy to sex or morphotype in such "problematic" walruses. We used 2D geometric morphometrics to quantify morphological differences among Plio-Pleistocene populations, in order to better understand the past diversity of *Ontocetus*, using a total of 21 specimens, including some new *Ontocetus* remains from the North Sea and Japan. We identified clear morphological variations among the different *Ontocetus* populations with some distinct size variations as specimens from the North Sea that are significantly larger than those from the U.S. East Coast. Moreover, in view of their similar characteristics to *Odobenus*, two mandibles from the North Sea recognized as *Ontocetus*, differ from what we known. This could suggest that those different populations of *Ontocetus* showed a wide spectrum of ecological adaptations.

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Education & Outreach Poster Session (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**ONCE UPON DEEP TIME: USING MUSIC AND ART TO COMMUNICATE EVOLUTION TO EVERYONE**

Bonnan, Matthew F.

Biology, Stockton University, Galloway, New Jersey, United States

The importance of scientific literacy and outreach are well-recognized for the benefits they bring to a country's citizens. Moreover, the public's natural curiosity about nature, paleontology, and our connections to the tree of life make these topics excellent vehicles for communicating science. The fusion of scientific content with music correlates with long-term retention of information and comprehension of scientific concepts.

Using my expertise in anatomy and paleontology, I created the outreach project Once Upon Deep Time, a pop/rock song cycle that uses music and art to tell the story about the evolution of hearing and our connection to the tree of life. The goal of the project is to communicate science via the fusion of musical storytelling and animation with the voice of an enthusiastic scientist. To increase their accessibility, the songs are pitched toward a lay audience of children and adults and are meant to inspire rather than being strict lessons in anatomy or evolution. Currently, six of the twelve songs also have accompanying animated music videos focusing on topics such as the origins of hearing, hearing in air, hearing and brain evolution in mammals, and echolocation. The music is available on all major streaming and download platforms, and the animated videos populate my YouTube channel as they are completed. The project has been a collaborative, interdisciplinary effort between students and faculty in the arts and sciences at Stockton University, along with the involvement of amateur and professional musicians and artists.

Preliminary feedback on prototype performances of the material from adult and college student audiences indicates the potential of Once Upon Deep Time to serve two purposes: 1) a way to educate middle school students through an interactive musical experience; and 2) as a stand-alone entertaining musical experience that inspires curiosity about our connection to the evolution of life. Both of these avenues are being explored. I am consulting with an education specialist and colleague to develop Once Upon Deep Time as an educational outreach tool for middle schoolers with a tentative roll out in 2024. Concurrently, I am working with another colleague with science, theater, and musical expertise to develop a more general, stand-alone production for a wider audience to premiere in Fall 2023.

**Funding Sources** Stockton University Research & Professional Development Committee

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**DESCRIPTION OF THE SMALLEST KNOWN SPECIMEN OF THE PLEURODIRAN SEA TURTLE *TAPHROSPHYS SULCATUS* FROM THE EDELMAN FOSSIL PARK, MANTUA TOWNSHIP, NEW JERSEY, AND IMPLICATIONS OF ONTOGENY ON ITS ECOLOGY**

Booth, Skylor L., Boles, Zachary

Geology, Rowan University, Northfield, New Jersey, United States

Vertebrate remains have been excavated from the Maastrichthian-Danian Hornerstown Formation for well over a century, and specifically have been found in abundance in the Main Fossiliferous Layer (MFL) of the Jean and Rick Edelman Fossil Park in Mantua Township, New Jersey. Within this layer, marine fauna are diverse, with the most common vertebrate material found from sea turtles. Here we describe new remains from a pleurodiran turtle, *Taphrosphys sulcatus*, which, to our knowledge, represents the smallest known individual yet described for the species. *Taphrosphys* is one of the first described bothremydid turtle genera to survive the K/Pg extinction. Larger specimens of this species are found abundantly within the MFL, and this new specimen allows for comparisons across a large ontogenetic range. Specifically, the anatomy of this new *Taphrosphys* was compared to two additional specimens found within the MFL. One of the specimens in comparison is the largest described thus far (RU-EFP-00001) and is thought to represent the oldest individual. The second specimen in comparison (RU-EFP-00002) represents an intermediate size and probable intermediate ontogenetic position between the RU-EFP-00001 and the new specimen. The anterior carapace is the best-preserved region of the specimens. Through

ontogeny, nuchal morphology lengthens anteroposteriorly, as well as loses the posterior process to form a flatter articulation with the first neural. This change influences carapace curvature which may hint at different ecological niches through ontogeny. Ongoing histologic analysis of costal elements supports differing degrees of costal porosity with the younger specimen exhibiting the densest bone and the older individuals exhibiting the most porous bone. Bone porosity in marine vertebrates has been found to reflect the environment in which the organism lived, with denser bone suggesting nearshore environments and more porous bone commonly associated with offshore dwelling organisms. In the case of *Taphrosphys*, increasing porosity with body size may mean older individuals spent more time out in open ocean than younger individuals. The description of this specimen and ontogenetic study of *Taphrosphys* provides key information on body size trends as well as sea turtle diversity and ecology through the K/Pg extinction event.

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Virtual Posters

**RAPID GROWTH IN A NEW LATE TRIASSIC POPOSAUROID FROM THE SOUTH AFRICAN KAROO BASIN**

Botha, Jennifer[1], Chapelle, Kimberley (Kimi)[1], Barrett, Paul[2], Benson, Roger[3], Seerane, Thabile[1], Tolchard, Federick[1], Choiniere, Jonah[1]

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Poposauroidea is a clade of Late Triassic pseudosuchian archosaurs with diverse body forms. It includes small, edentulous bipeds such as *Effigia okeefeae*, medium-sized, theropod-like animals such as *Poposaurus gracilis*, and larger-bodied, sail-backed, quadrupeds like *Arizonasaurus babbitti*. Despite their disparity in size, diet, lifestyle and posture, little is known about poposauroid growth with the exception of *Effigia* and *Poposaurus*, which exhibit very different bone tissue patterns from each other. Here, we present data from a new, recently discovered, giant (~1 tonne) poposauroid taxon (BP/1/8085) from the Rhaetian deposits of the lower Elliot Formation (Karoo Basin, South Africa). The cortices of the humerus and femur comprise a highly vascularized woven-parallel complex where primary osteons of parallel-fibered bone are distributed within an interstitial matrix that contains abundant, large, haphazardly arranged osteocyte lacunae. The vascular arrangements vary from plexiform (from the inner to mid-cortex) to longitudinally oriented primary osteons (towards the outer regions of the bones). Growth marks - lines of arrested growth and annuli - interrupt the rapidly forming tissues throughout the cortex. A maximum of 13 growth marks were observed in the humerus, 11 in the femur, and 12 in a rib. The zones between growth marks become narrower towards the subperiosteal surface and there is an increase in parallel-fibered bone indicating a decreased growth rate. BP/1/8085 is mature but not fully grown, as the External Fundamental System is absent. The new taxon is one of only a handful of pseudosuchian specimens known from the lower Elliot Formation and is one of the latest-surviving members of Poposauroidea. Its large body size and rapid growth pattern are more similar to those of *Poposaurus* than to the later-branching, small-bodied members of the Shuvosauridae, such as *Effigia*. These observations support ancestrally high growth rates in poposauroids and suggest that the slower growth in the more derived, smaller members of the group is derived independently from that of living pseudosuchians (Crocodilia).

**Funding Sources** This project was supported by GENUS, the Centre of Excellence in Palaeosciences, the National Research Foundation and the Palaeontological Scientific Trust.

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Paleontological Management Poster Session (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**ADVANCING FEDERAL PALEONTOLOGY MANAGEMENT THROUGH INTRA-AGENCY COLLABORATION IN THE NATIONAL PARK SERVICE**

Boudreau, Diana, Marsh, Adam D., Smith, Matthew E.

Petrified Forest National Park, Petrified Forest, Arizona, United States

At the heart of the Paleontological Resources Preservation Act (PRPA) is a collaborative approach by public land management agencies to preserve fossils on federal lands. This legislation provides fossil resource protections that may not be explicitly mentioned in the establishing legislation of individual

park units. PRPA's cooperative nature can allow for intra-agency collaboration to uphold PRPA rules. This is particularly important because trained paleontologists and fossil-focused museum professionals in the US federal government are limited relative to the abundance of fossil resources, especially when compared to cultural or biological resources. The adoption of PRPA regulations within each agency will necessitate hiring additional paleontology positions in the future, but for now, collaboration is a sound alternative to maintain paleontology management standards. In the National Park Service (NPS), over 280 park units contain fossils within their congressionally approved boundaries. Some park units were set aside principally because of their fossil resources and these have dedicated paleontologists, including Petrified Forest National Park (PEFO), Dinosaur National Monument, Badlands National Park, John Day Fossil Beds National Monument, Waco Mammoth National Monument, and others, but most parks send technical assistance requests to the Washington, D.C. paleontology office (WASO). With the enactment of PRPA and its NPS regulations, these requests have increased significantly, placing a large workload on limited WASO staff. As a result, WASO has reached out to PEFO staff for assistance in the Intermountain Region and beyond. Being located centrally in the western US and having robust paleontology and museum services programs with knowledgeable staff, PEFO has a unique opportunity to help with the increased need for formalized fossil resource management. In the last 5 years, PEFO assisted 17 other NPS units with fossil inventories, pre-construction surveys, fossil collections and salvage, monitoring plans, preparation projects, and fossil housing and curation. However, this collaboration is not unidirectional; other parks provided staff at PEFO with their expertise, as well. The tangible examples provided here highlight the type of collaborative work that upholds the regulations of PRPA, builds connections between federal paleontologists, and highlights the astounding fossil resources preserved on federal lands within the NPS.

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Technical Session 4: Dinosaur Soft Tissues (Wednesday, October 18, 2023, 1:45 PM)

**GEOCHEMICAL EXAMINATION OF DINOSAURIAN "MUMMIES" FROM THE HELL CREEK FORMATION REVEALS A PATHWAY FOR DERMAL TISSUE FOSSILIZATION**

Boyd, Clint A.[1], Drumheller, Stephanie K.[2], Householder, Mindy[3], Saini-Eidukat, Bernhardt[4], Nestler, Jennifer[5], Ullmann, Paul[6]

[1]Paleontological Resource Protection, North Dakota Geological Survey, Bismarck, North Dakota, United States, [2]Department of Earth and Planetary Sciences, University of Tennessee–Knoxville, Knoxville, Tennessee, United States, [3]State Historical Society of North Dakota, Bismarck, North Dakota, United States, [4]Department of Earth, Environmental and Geospatial Sciences, North Dakota State University, Fargo, North Dakota, United States, [5]Independent Researcher, Fort Collins, Colorado, United States, [6]Department of Geology, Rowan University, Glassboro, New Jersey, United States

A recent taphonomic study of a well-preserved specimen of *Edmontosaurus* (NDGS 2000) revealed a simple pathway for dermal tissue stabilization prior to burial, raising the question of why fossilized dermal tissues (e.g., skin, nails) are not more commonly recovered. A possible explanation is that the geochemical processes through which more durable tissues like bone are fossilized are not sufficient for high fidelity preservation of dermal tissues. To investigate this question, we conducted a systematic survey of the chemical composition of the bones, dermal tissues, and encasing matrix of two dinosaurian "mummies" (NDGS 2000 and MOR 979 [*Thescelosaurus* sp.]) from the Hell Creek Formation using a Niton XL5 pXRF spectrometer. Hierarchical and K-means cluster analyses of >200 scans reveal that bone samples cluster separately from matrix and dermal tissue samples. While matrix and dermal tissue samples were imperfectly clustered, resulting from overlap between poorly-preserved dermal tissues and well-mineralized matrix, a gradational trend is noted. Matrix samples far from preserved dermal tissues exhibit enrichment in Ca and light elements (e.g., O, C, H). Moving towards and into the soft tissues the proportions of those elements decrease, while the concentrations of Fe, Mn, P, S, and Ni all increase. Well-preserved dermal tissues occur in regions where old fractures are present in the encasing rock that are surrounded by halos of altered matrix, with those halos also surrounding well-preserved dermal tissues. Those fractures formed after initial cementation of the rock by carbonate minerals (e.g., calcite, possibly siderite) during the development of an inferred overlying paleosol, allowing surficial waters of differing chemistry to interact with the specimen and adjacent matrix. Examination of field photographs confirms the presence of a paleosol overlying NDGS 2000. Petrographic analysis of the matrix in those altered regions in NDGS 2000 revealed that the original carbonate cement was dissolved and replaced by iron oxides (e.g., goethite) and later sulfides (e.g., pyrite). It appears that this dissolution/re-mineralization process was responsible for the influx of Fe, Mn, P, S, and Ni to the dermal tissues. We propose this pattern of multiple phases of mineralization under very specific depositional conditions both enhances the quality and long-term stability of fossilized dermal tissues and may also account for their rarity in the fossil record.

**Funding Sources** This research was funded by the David B. Jones Foundation.

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Technical Session 20: Marine Mammals & Bats (Saturday, October 21, 2023, 1:45 PM)

**SHARING A MORPHOSPACE: USING ELLIPTIC FOURIER ANALYSIS TO (NOT) IDENTIFY HETERODONT CETACEAN CHEEK TEETH**

Brand, Nickolas A.[1], Nelson, Margot D.[1], Peredo, Carlos M.[2], Uhen, Mark D.[3]

[1]Environmental Science and Policy, George Mason University, Fairfax, Virginia, United States, [2]Biological Sciences, Miami University, Oxford, Ohio, United States, [3]Atmospheric, Oceanic & Earth Sciences, George Mason University, Fairfax, Virginia, United States

Isolated heterodont cetacean teeth are recovered worldwide from Eocene, Oligocene and Miocene marine sediments. Despite a long history of taxonomic names established for heterodont cetaceans based solely on teeth and fragmentary remains, it remains unclear if teeth provide a morphological signal strong enough to allow for confident identification at a higher resolution than Cetacea. Elliptic Fourier analysis allows for comparison of shape in two dimensions via conversion into mathematical functions. This technique has recently been used to determine taxonomic identity of archaeocete dentition and is here utilized to attempt identification of eight unknown heterodont cetacean teeth via comparison to specimens with well-established taxonomic identifies. A dataset of over sixty teeth was assembled by photographing double rooted cheek teeth from clearly heterodont archaeocetes, mysticetes and odontocetes. Additional photos were collected from high quality published images. Teeth were selected to maximize morphological variation within species, such that results would be most representative of true variation. Tooth crown outlines were created in Krita, and modified so that differences in the basal margins of the root-crown junction were minimized. Outlines were processed in RStudio with the Momocs and deployr packages, using twenty-seven harmonic coefficients such that 99.9% of shape variation was captured. Premolars and molars were analyzed separately, and the first five principal components (PC) were nearly identical for both groups. Concavity of the posterior tooth margin (PC1), crown height/width ratio (PC2), and crown sharpness (PC3), accounted for the majority of variation in tooth shape. Comparisons between the PCs 1-3 revealed considerable overlap in morphospace between the archaeocetes, odontocetes and mysticetes, though archaeocetes were consistently restricted along PC2 compared to neocetes. Discriminant function analysis was performed in PAST for all comparisons of PCs 1-3 for premolar and molar groups. Correct classification of known specimens occurred at a rate of only 49.6%. Of eight unknown specimens, only four were classified consistently. These results call into question the ability to identify isolated heterodont cetacean cheek teeth using overall shape or outline, even when relying on comparison to teeth with confident identification. This also casts doubt on the validity of cetacean taxonomic names established using isolated teeth.

**Funding Sources** Funding for this research was provided by the George Mason University Department of Environmental Science and Policy, via the Presidential Scholarship.

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Technical Session 18: Synapsids (Saturday, October 21, 2023, 8:00 AM)

**EARLIEST OCCURRENCE OF AN INOSTRANCEVIID GORGONOPSIAN IN SOUTHERN PANGEA: PRELIMINARY DATA FROM THE USILI FORMATION OF TANZANIA**

Brant, Anna, Sidor, Christian A.

Department of Biology and Burke Museum of Natural History and Culture, University of Washington, Seattle, Washington, United States

Gorgonopsia is a clade of sabre-toothed carnivorous therapsids that occupied some of the top predatory niches during late Permian times. Their fossils are most abundant in the Karoo Basin of South Africa, but are also relatively common components of coeval Malawian, Tanzanian, Zambian, and Russian assemblages, with more sporadic records in Niger and China. Recent phylogenetic analyses have demonstrated that African gorgonopsians form a monophyletic subclade distinct from their Russian relatives, which all fall out near the root of the cladogram, thus suggesting a northern hemisphere origin for the clade. Large body size evolved independently within the Russian clade Inostraceviidae and the southern African clade Rubidgeidae, with skulls approaching or exceeding 50 cm in both groups. Surprisingly, recent research has demonstrated that a species of *Inostrancevia* occurs in the upper *Daptocephalus* Assemblage Zone of the Karoo Basin, perhaps the result of immigration following the demise of rubidgeines in the lower subzone of that unit.

Here we describe a large, isolated gorgonopsian premaxilla from a bone-rich interval at the base of the Usili Formation of Tanzania's Ruhuhu Basin, the basal conglomerate. Based on its stratigraphic position and fossil content, the locality likely correlates with the *Cistecephalus* Assemblage Zone, although an *Endothiodon* zone age is also possible. Importantly, the conglomerate preserves taxa rarely found elsewhere in the Usili, such as burnetiamorphs and temnospondyls. The premaxilla can be confidently referred to the family Inostranceviidae on the basis of its four incisors, a feature unique to inostranceviids among gorgonopsians. The discovery of a second inostranceviid in Africa raises new questions about the group's biogeographic history. In contrast to the disjunct distribution of inostranceviids and rubidgeines in the latest Permian of South Africa, the Tanzanian inostranceviid likely overlapped with rubidgeines such as *Dinogorgon* and *Rubidgea/Titanogorgon*, thereby casting doubt on the hypothesis that northern latitude immigrants were excluded by southern African endemic rubidgeines.

**Funding Sources** NSF EAR-1337569

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Paleontological Management Poster Session (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**THE PHOTOGRAMMETRIC REVOLUTION: TWENTY-FIVE YEARS OF PHOTOGRAMMETRY FOR PRESERVATION AND MANAGEMENT OF PALEONTOLOGICAL RESOURCES (1998-2023): PRESERVING ANCIENT ECOSYSTEMS AND AMERICA'S NATURAL HERITAGE**

Breithaupt, Brent H.[1], Matthews, Neffra A.[2], Noble, Tommy[2]

[1]Wyoming State Office, Bureau of Land Management, Cheyenne, Wyoming, United States, [2]Retired, National Operations Center, Bureau of Land Management, Denver, Colorado, United States

Photogrammetry (the art and science of deriving 3-D data and images from carefully collected stereo photographs) is now an established practice in paleontological documentation. While photogrammetry began as a discipline over 150 years ago, it was sparsely used in paleontology until relatively recently. A notable exception was the documentation of Pliocene hominid footprints at Laetoli in Tanzania in the 1970s. In 1997, the discovery of Middle Jurassic theropod footprints in Wyoming at the Red Gulch Dinosaur Tracksite (RGDT) heralded in a new era in ichnological documentation and tracksite management. As vertebrate trace fossils reflect the complex interrelationship between an animal's activities and the substrate, they warrant detailed recordation that captures their multidimensional features. Management decisions to use the best science to capture the paleontological values of the RGDT led to it becoming one of the most thoroughly documented fossil tracksites in the world, as state-of-the-art photogrammetric techniques were integrated in GIS with traditional ichnological methods. As with Laetoli, early work at RGDT was laborious and time consuming, but rewarding. Bureau of Land Management (BLM) staff spearheaded the use of close-range photogrammetry at RGDT and refined photogrammetric ichnologic techniques at other dinosaur tracksites throughout the American West. Over a quarter century of stereo imagery, taken from a variety of platforms (handheld to aerial) allowed for refinement of the disciple. Today, photogrammetry is used to help unravel numerous ichnological mysteries of ancient animal communities. It has also proven to be invaluable for making scientific-based management decisions for the preservation of in situ paleontological resources, especially for gathering baseline data that can be used for condition assessment and degradation monitoring. With advances in digital cameras and processing software, photogrammetry has become one of the easiest, noninvasive, cost-effective methods for 3D digital documentation of fossils in the field. Photogrammetric work pioneered on BLM tracksites has spawned companion studies around the world, including 3D visualization of body fossils, as well as artifacts and archeological sites. Photogrammetry and other digital data collecting techniques help federal agencies fulfill their mission (à la PRPA) to assess, inventory, manage, and interpret paleontological resources using scientific principles and expertise.

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Education & Outreach Poster Session (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**UTILIZING AN INTERNAL GRANT TO SUPPORT GENDER EQUITY IN THE GEOSCIENCES AT THE UNIVERSITY OF SOUTHERN MISSISSIPPI**

Brink, Alyson A.

School of Biological, Environmental, and Earth Sciences, University of Southern Mississippi, Hattiesburg, Mississippi, United States

The University of Southern Mississippi (USM) recently established several initiatives to increase diversity, equity, and inclusion on campus. One of the initiatives, GEMS (Gender Equity Movement in STEM), awards four $5000 grants to faculty for projects supporting gender equity in STEM disciplines. One of the projects selected for the 2022 inaugural award supported two undergraduate geology majors in the Geology program during the Fall 2022 semester.

Entitled Recruit, Retain, Train: Supporting Diversity, Equity and Inclusion of Persons Historically Excluded from Geological Sciences, the project proposed in part to financially support two geology students to work in the Brink “Bones & Teeth” vertebrate paleontology lab. The selected students, a white female in their senior year and a black female in her junior year, had no previous lab experience. As well, although both had considered pursuing an advanced degree in the future, they were unfamiliar with the process and had not determined a specific discipline of interest.

For 14 weeks during the Fall 2022 semester, each student was paid $16 an hour to work in the lab for 10 hours each week, and learned paleontological techniques including extracting and re-assembling macrofossils, wet sieving matrix and drying the resulting concentrate, picking microvertebrate fossils using microscopes, and curating the resulting specimens. They also received one-on-one mentoring for two hours each week.

Results from this project include the following: the senior student continued to develop their project and in Spring 2023 was awarded first-place for their oral presentation to the Geology & Geography division at the Mississippi Academy of Sciences (MAS) conference. The senior student also applied for and was accepted into the graduate program at USM and will begin a Teaching Assistantship to study vertebrate paleontology in Fall 2023. The junior student continues to work in the vertebrate paleontology lab and will present results of her research at the 2024 MAS conference. She recently expressed her intent to apply for graduate school at USM and study vertebrate paleontology.

**Funding Sources** GEMS grant (Gender Equity Movement in STEM), The University of Southern Mississippi, Jimmy Payne Foundation

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**CARNASSIAL RELATIVE BLADE LENGTH (RBL) AS AN INDICATOR OF CARNIVORAN DIETARY ECOLOGY**

Brown, Isaac, Clarke, Triniti, Vick, Duncan, Lawing, Michelle, Siciliano-Martina, Leila

Texas A&M University, Mesquite, Texas, United States

Carnivorans exhibit a wide variety of diets, ranging from the herbivorous diet of the giant panda (*Ailuropoda melanoleuca*) to the obligate carnivory observed in felids. The length of the trigonid blade relative to the total carnassial tooth length (known as the relative blade length, or RBL) is functionally related to shearing and grinding ability in terrestrial carnivorans, where a greater RBL value correlates to a greater degree of carnivory. To explore the nature of this relationship, we extracted RBL values from published studies representing a sample of over 200 fossil and extant carnivoran species. These data allowed us to evaluate the variation in RBL values across Carnivora and provided new areas of inquiry. There is a clear distinction in RBL values between most extant caniforms and feliforms. The caniforms (e.g., bears, skunks, martens) possessed a wide range of RBL values under 0.8, suggesting that members of the group typically have a less carnivorous and more generalist diet than felids and their closest relatives. Felids had high, uniform RBL values of 1.0, leading to further questions about the ecological and evolutionary limits to the morphospace associated with this functional trait. Dental measurements of fossil specimens were used to track this morphological disparity through time, revealing an early appearance of maximal RBL values in the evolution of Carnivora. Overall, the reliability of relative blade length as a dietary indicator and its presence in many taxa provides a useful pathway for research into the evolution of this diverse and ecologically vital taxonomic order.

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Preparators' Poster Session (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**QUANTIFYING THE IMPACT OF FOSSIL PREPARATORS THROUGH TIME**

Brown, Matthew

Jackson School Museum of Earth History, The University of Texas at Austin, Austin, Texas, United States

Nearly every fossil described in a scientific publication undergoes preparation prior to research. At times, exposure of fossil data from a rock matrix merely requires a few minutes with a toothbrush and water. In other cases, preparation can entail thousands of hours of intricate and invasive treatment methods applied to fossils to make them ready for study. Fossil preparators are highly skilled paleontologists who draw on their knowledge of geology, anatomy, chemistry, and specialized equipment and techniques to accurately reveal and preserve scientific data. Preparators typically contribute this labor behind the scenes in an institution and are customarily (but not always) credited through acknowledgment in any resulting publications. Rarely are preparators' contributions to the collection, preparation, and identification of data recognized with authorship. Additionally, the lack of professional accreditation or certification available to preparators can make it difficult for a preparator to establish their own relative contribution to the scientific enterprise. It is similarly difficult for hiring officials to evaluate the experience of job applicants, or for non-specialist managers to conduct performance appraisals.

A popular metric for quantifying contributions of individual scientists is the *h*-index, a simple formula for comparing the productivity and research impact of scientists based on the number of citations to their published research, where *h* represents the number of *h* articles having a minimum of *h* citations each. In recent years, several museums began calculating the *h*-index of entire collections to demonstrate the scope and impact of their use. This modification aggregates all the publications and number of citations by researchers during specimen-based research in each collection. In this project, I further adapted the application of an *h*-index concept as an exercise in estimating the contributions of the non-publishing scientists who facilitate paleontological research. This process aggregated papers based on specimens an individual had prepared and calculated an *h*-index using a purpose-built Google Scholar profile. Although this metric is subject to the same criticisms as the conventional *h*-index as an imperfect tool for evaluating the totality of an individual's contributions, this study demonstrates that an uncredited member of a research team can still have an equivalent quantifiable impact on the science as other project personnel.

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Technical Session 3: Fishes & Amphibians (Wednesday, October 18, 2023, 8:00 AM)

**A GIANT RAPTORIAL BOWFIN (OSTEICHTHYES: HALECOMORPHI) FROM THE PALEOGENE OF NORTH AMERICA**

Brownstein, Chase D.

Yale University, New Haven, Connecticut, United States

Aquatic biodiversity changed dramatically at the start of the Paleogene. Although little is known about global freshwater ecosystems that appeared just after the end-Cretaceous mass extinction, available data suggest that they were buffered from the worst environmental effects of the extinction event. Here, we describe a nearly complete skeleton of one of the largest known freshwater fishes from a subtropical wetland ecosystem that existed fewer than ten million years after the end-Cretaceous extinction in western North America. With a maximum length of approximately 3 meters, †*Amia basiloides* sp. nov. is the largest species of Holostei, an once species-rich clade of ray-finned fishes now survived by nine species of 'living fossil' gars and bowfins. High-resolution computed tomography scans show that †*Amia basiloides* possessed adaptations for a raptorial lifestyle and represents an analogue to living megapredatory freshwater fishes found only in the southern hemisphere. When considered in a phylogenetic context, †*Amia basiloides* shows that close relatives of living bowfins rapidly achieved gigantism in the earliest Paleogene of North America after the largest members of an ancient sister clade to bowfins went extinct. Although the Cretaceous-Paleogene boundary likely induced significant turnover of freshwater vertebrate predatory guilds, these faunas remained ecologically comparable across the extinction due to exceptionally fast episodes of convergence in holosteans and other clades of freshwater fishes.

**Funding Sources** Yale Peabody Museum Summer 2021 Internship

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

### JUVENILE SKULLS OF *COELOPHYSIS BAURI* FROM GHOST RANCH, NEW MEXICO

Bugos, Jeb E.[1], McDavid, Skye N.[2]

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*Coelophysis bauri* is a theropod dinosaur well known from the famous late Triassic (Norian-Rhaetian) mass death assemblage at the Ghost Ranch *Coelophysis* Quarry in New Mexico. Among the smallest individuals from this quarry are CMNH 50957 and MCZ 4326. CMNH 50957, a mostly articulated skull associated with two cervical vertebrae, includes most of the cranium and mandible, but is missing the premaxilla and sclerotic rings. MCZ 4326 is also mostly articulated and lacks a premaxilla, though it does preserve a partial sclerotic ring. Notably, both specimens preserve hyoids, meaning they are excellent candidates for hyoid histology.

The proportions of these two skulls are different from other *Coelophysis* skulls from the same quarry, especially in their large orbits, short and flat triangular teeth, and thin bones. In these respects, they resemble juveniles of other theropod clades. Despite extensive study of Coelophysoid postcranial ontogeny and Tyrannosauroid cranial ontogeny, literature on Coelophysoid cranial ontogeny remains sparse. This research presents a detailed osteological description of two relatively complete juvenile Coelophysoid skulls.

CMNH 50957 and MCZ 4326 have many features in common with juvenile and putative adult skulls of *Megapnosaurus rhodesiensis*, a relative from Southern Africa which has at times been proposed to be congeneric with *C. bauri*. These skulls do not definitively support generic synonymy or generic separation between *Coelophysis* and *Megapnosaurus*, though they serve as a cautionary tale: some features previously proposed to differentiate the two are ontogenetically variable. *Megapnosaurus* and *Coelophysis* are retained as separate genera on the basis of morphological differences between adults and recent phylogenetic analyses.

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Technical Session 21: Squamates (Saturday, October 21, 2023, 1:45 PM)

### A POTENTIALLY VENOMOUS LIZARD-LIKE REPTILE FROM THE LATE TRIASSIC (NORIAN) OF THE SOUTHWESTERN UNITED STATES

Burch, Helen E., Eddins, Hannah-Marie, Stocker, Michelle R., Nesbitt, Sterling J.

Geosciences, Virginia Tech, Blacksburg, Virginia, United States

Reptile feeding strategies encompass a wide diversity of methods for subduing prey. One such strategy, the use of venom for prey capture, is found in living reptile clades like helodermatid (beaded) lizards, monitor lizards, and iguanians, and is widespread among snakes. Whereas the fossil records for some of these groups show strong evidence for venom use, this feeding strategy has also been hypothesized for a variety of extinct reptiles (e.g., archosaurs, ancient anguimorphs, a sphenodontian). However, evidence of systems for venom delivery in extinct groups (or which point to origins of venom systems) has been scarce. Here, we describe a potentially venomous new reptile from a partial left dentary recovered from the Sonsela Member of the Chinle Formation (mid-Norian, Late Triassic) of northeastern Arizona. The three dentary teeth have apexes which are distally reclined relative to their bases, and the tip of the posteriormost tooth curves anteriorly. The teeth show sub-thecodont implantation and are interspaced by empty sockets that terminate dorsally to Meckel's groove, which is dorsoventrally expanded posteriorly. Replacement teeth alveoli are positioned mesiodistally to the active teeth as in varanid-like replacement. We identify this new specimen as a diapsid reptile on the basis of its monocuspid teeth with smooth exterior surfaces (absence of carinae on mesial and distal surfaces and absence of serrations). Several features of this new taxon (such as an intramandibular septum) are shared with some anguimorph lizards; however, these may be independently derived. The teeth are distinctively marked by superficial grooves that extend the length of the crown on the labial and lingual sides, as seen in the teeth of living beaded lizards for venom delivery. If these grooves are functionally similar to those of beaded lizards, this new taxon represents the oldest reptile with venom conducting teeth found within a jaw. The teeth of the new species are 10 times smaller than those of the only other known Late Triassic venomous reptile, *Uatchitodon*, supporting venom use across multiple body size classes. Prey capture strategies are often difficult to estimate from fossils, and yet are essential to understanding ecology for ancient animals – this discovery of a strategy well recognized in extant taxa lets us know that venom was similarly beneficial to small vertebrates in the Late Triassic as both prey and predators of small-bodied reptiles diversified.

**Funding Sources** Virginia Tech Department of Geosciences, National Science Foundation

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Technical Session 15: Paleoecology & Paleoclimatology (Friday, October 20, 2023, 1:45 PM)

**EOCENE FOREST COMMUNITIES AND THE EXTINCTION OF MULTITUBERCULATE MAMMALS**

Burger, Benjamin

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Multituberculates were an incredibly long-lived mammalian lineage that survived the end-Cretaceous mass extinction but became extinct during the Eocene Epoch. Previous research has suggested that competition with rodents lead to this decline. This study looked at the biogeographical occurrences of Eocene multituberculates (including genera *Neoliotomus*, *Ectypodus*, and *Parectypodus*) as well as six families of Eocene rodents and compared them with the paleobotanical record by measuring three computational parameters for each plant-mammal pairing to determine each group's preferred forest habitat. These parameters included: 1) The number of plant occurrences in a constructed mammal polygon shape based on fossil localities (NOP) 2) the ellipsoid distance between a similar plant polygon shape and mammal polygon shape's centroid (geometric barycenter) or ellipsoid distance (ED) and 3) the area of nonoverlap between the mammal polygon and the fossil plant polygon referred to as NOLA. Each value was calculated and ranked for each pairing. Based on combined NOP, ED, and NOLA rankings multituberculates were found to be strongly associated with forest communities dominated by dawn redwood (*Metasequoia*), Chinese swamp cypress (*Glyptostrobus*), alder trees (*Alnus*), and cone nut trees (*Platycarya*), which bear seeds in small cone-like structures in cooler wetter northern forests. Eocene rodent families Ischyromyidae, Cylindrodontidae, Sciuravidae, Eutypomyidae, and Eomyidae were associated with forest communities dominated by chestnut, acorn and oak trees, softer legume plants and ficus and mulberry trees, and fruit-bearing guava trees, with a slight affinity to cone nut trees in later Eocene eutypomyid and eomyid rodents. The rodent family Protoptychidae showed no geographic overlap with Eocene multituberculates, likely preferring southwestern forests dominated by sycamore, elm, willow and walnut. Results suggest that multituberculate extinction was not driven by direct competition with rodents, but that Eocene forest structure fundamentally changed during the Eocene, as dawn redwood and Chinese swamp cypress forests were replaced by boreal forests composed of spruce, fir, pine and popular trees toward the end of the Eocene Epoch.

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Technical Session 14: Crocodylomorphs & Turtles (Friday, October 20, 2023, 1:45 PM)

**NEUROANATOMICAL FEATURES HELP ELUCIDATE THE EVOLUTIONARY HISTORY OF GAVIALOID CROCODYLIANS**

Burke, Paul M., Mannion, Philip D.

University College London, London, United Kingdom

The interrelationships of Crocodylia have been subject to debate for decades, particularly pertaining to the extant longirostrine species, *Gavialis gangeticus* and *Tomistoma schlegelii*. Molecular analyses show a sister taxon relationship between these two gavialid species, whereas morphological analyses typically recover *Gavialis* as the outgroup to all other extant crocodylians. Recent morphological analyses have resolved this discrepancy, recovering the molecular topology; however, a temporal incongruence remains, with numerous putative gavialids from stratigraphic units that greatly predate *Gavialis-Tomistoma* molecular divergence time estimates. We evaluated the neuroanatomy of numerous fossil gavialoids (the more inclusive clade that includes gavialids), with the eventual aim to develop new characters to incorporate into a morphological phylogenetic dataset. Using CT scans, we found that the neuroanatomy of *Tomistoma dowsoni*, a fossil gavialoid from the Miocene of North Africa, has an intermediate morphology between the two extant species, more closely resembling *Gavialis*. Preliminary results from reconstructing the neuroanatomy of other gavialoids indicate that the recently extinct Chinese species *Hanyusuchus sinensis* is morphologically more similar to *Gavialis gangeticus*, whereas the Miocene Austrian taxon *Gavialosuchus eggenburgensis* more closely resembles *Tomistoma schlegelii*. The neuroanatomy of *Eothoracosaurus mississippiensis*, a potentially 'problematic' taxon within Gavialoidea given its Late Cretaceous age, appears to show a close resemblance to *Gavialis*, indicating that perhaps gavialid neuroanatomical features evolved early in Gavialoidea, remaining relatively conserved across the clade. We tested this in a Principal Components Analysis, in which PC1, showing 80% of variation in neuroanatomical morphology, grouped all of the gavialoid species thus far evaluated together, separate from other species of Crocodylia, with the most notable differences in cerebrum, nasolacrimal duct, and nasal cavity morphologies. Via comparison to other longirostrine crocodyliform species, we can gain further clarity over when certain features evolved, whether specific features are unique to gavialoids, and subsequently determine their importance in inferring gavialoid phylogeny and ecomorphology.

**Funding Sources** Leverhulme Trust. Grant Number: RPG-2021-2022
Royal Society. Grant Numbers: RGF\EA\201037, UF160216

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

### EVIDENCE OF OSTEOLOGICAL PATHOLOGIES IN LATE PLEISTOCENE COLUMBIAN MAMMOTHS (*MAMMUTHUS COLUMBI*) AT WACO MAMMOTH NATIONAL MONUMENT, WACO, TEXAS, USA

Butler, Dava K.[1], Yann, Lindsey T.[2], Peppe, Daniel J.[1]

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Osteological pathologies are a common, yet under-reported, feature in the vertebrate fossil record. Under the One Health framework, the health of plants, animals, and humans is inextricably tied to the health of their ecosystem, as many pathologies derive from environmental factors. By extension, paleopathologies may record past environmental conditions. Waco Mammoth National Monument (WMNM), a syndepositional assemblage of 18 *Mammuthus columbi*, other mammals, and herpetofauna, represents an opportunity to assess the health of a Late Pleistocene paleoenvironment. Due to taphonomic processes, non-mammoth fossils from the site tend to be isolated, fragmentary bones. In contrast, most of the mammoth fossils are relatively complete and often articulated. By withstanding the destructive processes of their deposition, these fossils provide a record of the paleoenvironmental health of central Texas ~66 ka.

Visual inspections of *in situ* specimens and those archived at Baylor University's Mayborn Museum were used to create the first survey of osteological pathologies for WMNM. Pathologies are categorized as typical (common and/or age-related) or atypical (rare and/or debilitating) and are expressed as percentages. Overall frequency (OF) is the percentage of the population with any pathology. Acute frequency (AF) is the percentage with atypical pathologies. Based on this assessment, *M. columbi* from WMNM have a 44-56% OF and a 33-44% AF. This frequency is considerably higher than other Pleistocene proboscidean populations described in the literature. *M. primigenius* (n=33) from Sevsk, Russia, have an 18-21% OF and a 15% AF. *Notiomastodon platensis* (n=47) from Águas de Araxá, Brazil, have a 6% OF and a 4% AF. The pathology frequency in modern, free-living elephants is unknown; however, a survey of AZA-accredited zoos provides an OF for musculoskeletal pathologies in captive elephants. Within those facilities, the OF for *Loxodonta africana* (n=98) is 22% and for *Elephas maximus* (n=100) is 28%. The apparently high prevalence of osteological pathologies in the mammoths at WMNM may indicate unfavorable environmental conditions, genetic anomalies in a diminished local population, or a combination of both stressors. These results both emphasize the importance of reporting pathological occurrences at fossil sites and provide context for the study and conservation of extant elephants.

**Funding Sources** National Park Service Graduate Fellowship, Mayborn Museum Bryce C. Brown Research Fellowship.

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Technical Session 9: Sauropsids (Thursday, October 19, 2023, 1:45 PM)

**A NEW PROCOLOPHONID FROM THE LATE TRIASSIC FISSURE FILL AT CROMHALL QUARRY, SOUTHWEST ENGLAND**

Butler, Richard[1], Meade, Luke[1], Cleary, Terri[1], McWhirter, Kai[1], Brown, Emily[2], Fraser, Nicholas[3], Kemp, Tom[4], Benito, Juan[5]

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The fissure fill localities of southwest England and South Wales are well-known for preserving rich assemblages of predominantly small-bodied Late Triassic to Early Jurassic tetrapods, but many aspects of the fissures remain contentious. The age of the Late Triassic fissures has been disputed, with lines of evidence (e.g., biostratigraphy) suggesting a latest Triassic (Rhaetian) age, whereas others including as-yet-unpublished radioisotopic dates suggest an older origin, potentially dating to the Carnian. The fissures are hypothesized to have formed on an archipelago, and island effects have been invoked to explain aspects of the assemblages such as the abundance of small-bodied species. Description of additional fossil material as well as re-evaluation of historically described species is necessary to test many of the hypotheses about these assemblages. Procolophonids were a successful group of primarily Triassic parareptiles, best known from Early to early Late Triassic assemblages, but have only recently been described from one fissure fill (Ruthin) based upon fragmentary jaw and dental remains. Here, we describe new procolophonid specimens from another fissure (Cromhall) that represent at least six individuals of different sizes, with much of the skeleton represented including well-preserved skull material. The Cromhall procolophonid shows strong similarities to Late Triassic leptopleuronine procolophonids, but both autapomorphies and a unique character combination demonstrate that it represents a new species. Phylogenetic analysis places the Cromhall procolophonid in a derived clade within Leptopleuroninae, together with *Leptopleuron*, *Hypsognathus* and *Soturnia*. Strong similarities to *Leptopleuron* in particular are consistent with the hypothesis of an early Late Triassic age for at least some of the Cromhall assemblage. The largest specimens demonstrate a body size for the Cromhall procolophonid that is similar to *Leptopleuron* and *Hypsognathus*, supporting recent work on trilophosaurids and coelophysoid theropods that has questioned the insular dwarfism hypothesis.

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Technical Session 4: Dinosaur Soft Tissues (Wednesday, October 18, 2023, 1:45 PM)

**VERTEBRAL MORPHOLOGY AND HISTOLOGIC CORRELATES OF CARDIOPULMONARY EVOLUTION IN TERRESTRIAL AND AQUATIC ARCHOSAURIA: CASE STUDY OF A SECONDARILY AQUATIC BIRD *AECHMOPHORUS***

Byrne, Paul J.[1], Smith, Nathan D.[2], Irmis, Randall[3], Huttenlocker, Adam[4]

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The evolutionary origins of the crocodylian-style hepatic piston and avian-style air sac pulmonary systems are enigmatic due to the rarity of soft-tissue preservation in archosaur fossils. However, archosaur lung embryology suggests a shared ancestral condition. Additionally, there is increasing evidence that the ability to sustain higher systemic blood pressures and higher aerobic capacity may have been ancestral in Archosauria. Here, we ask: Are there reliable fossilizable indicators of cardiopulmonary evolution? And do they reveal divergent patterns in terrestrial versus secondarily aquatic archosaur lineages? We present a combined study that uses: 1) macroscopic (fossae, laminae, foramina) vertebral features in over 230 extinct and extant archosaurs and 2) microscopic (pneumosteum) thin sections in 18 extant archosaurs to assist in hypothesizing the

presence of pulmonary diverticula in the axial skeleton. Assessing states in Triassic taxa will clarify whether pseudosuchians always lacked these features or lost them secondarily in the later Crocodylomorpha.

Preliminary results on the secondarily aquatic grebe, *Aechmophorus occidentalis* (Western Grebe), show that both external pneumaticity and pneumosteum are absent in the axial column. This suggests that the air sac-style pulmonary system can be present despite the absence of pneumaticity and pneumosteum, and that these features are lost when transitioning to an aquatic lifestyle. In addition, all of the sampled extant terrestrial archosaurs in which pneumosteum is found also exhibited external pneumatic foramina. Within the fossil taxa examined, 35 of the 54 early-diverging, terrestrial pseudosuchians exhibited specialized vertebral morphology with pneumatic fossae more similar to early avemetatarsalians than to extant crocodylians, and several of these exhibit pneumatopore-like foramina—suggesting the axial skeleton may have been associated with pneumatic diverticula. These new data, combined with the presence of apomorphies that allow for cardiac shunting in extant crocodylians, leads us to hypothesize the shift to the extant ‘hepatic piston’ pulmonary style in crocodylomorphs may have corresponded with changes in cardiovascular morphology–allowing for prolonged submersion in a secondarily aquatic environment.

**Funding Sources** University of Southern California, Natural History Museum of Los Angeles County

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Technical Session 7: Birds (Thursday, October 19, 2023, 8:00 AM)

### PATTERNS OF POSTCRANIAL SUTURE CLOSURE IN THE EMU (*DROMAIUS NOVAEHOLLANDIAE*) WITH IMPLICATIONS FOR THE INTERPRETATION OF ONTOGENETIC STAGES IN ARCHOSAURS

Caldwell, Heath R., Bedolla, Emilio, Varricchio, David J.

Earth Sciences, Montana State University, Clancy, Montana, United States

Determining the relative ontogenetic stages of extinct archosaurs, such as non-avian dinosaurs, has been the subject of intensive study through a variety of approaches. Numerous studies have used the neurocentral suture closure patterns observed in crocodylians as a baseline for determining the ontogenetic stage of various dinosaur specimens, despite being distantly related. Given their phylogenetic closeness and physiological similarities, there are likely many archosaur groups where it is more appropriate to use the emu (*Dromaius novaehollandiae*) as an ontogenetic analogue as opposed to extant crocodylians. By describing the range of variability in suture closure patterns in extant archosaurs, the expected range of patterns in extinct members of the group can be constrained. Here, we describe the patterns of suture closure in the postcranial skeleton of *D. novaehollandiae* using multiple individuals, spanning a near total range of ontogenetic stages for this taxon. Through ontogeny, neurocentral suture closure begins cranially and caudally before progressing towards the synsacrum in *D. novalehollandiae*, as opposed to the caudal-cranial directionality observed in crocodylians. Neurocentral suture closure in the non-sacral vertebrae occurs early in ontogeny and precedes suture closure in appendicular elements and synsacrum. Suture closure patterns in *D. novaehollandiae* appear to be similar to what is observed for troodontids. Not only do these results offer new data for assessing the maturity of some extinct archosaurs, but they also highlight the variability of suture closure patterns throughout Archosauria, and the need for greater scrutiny when interpreting the ontogenetic stages of extinct archosaur individuals.

**Funding Sources** Varricchio Family Paleontology Laboratory - Montana State University
Montana Emu Ranch

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Virtual Posters

### A NEW PALEONTOLOGICAL RESOURCES MANAGEMENT PLAN FOR DENALI NATIONAL PARK AND PRESERVE

Capps, Denny, Brease, Phil, Hilburn, Samantha, Santucci, Vincent

National Park Service, Denali Park, Alaska, United States

Denali National Park and Preserve (DENA) contains an incredible quality, quantity, and diversity of non-renewable paleontological resources warranting further survey, inventory, monitoring, protection, and public interpretation. More than a century of ongoing geological survey and paleontological discovery at

DENA provides insight into the tectonic, climatic, and biotic evolution of Interior Alaska. Marine and terrestrial ichnofossils, vertebrate and invertebrate fossils, and paleobotanical fossils of Paleozoic, Mesozoic, and Cenozoic age found at DENA have implications for past, present, and future ecological regimes and regime shifts. The paleontological record of DENA documents Earth history spanning more major divisions of geologic time than all but one other unit in the National Park System.

To issue the specific guidance necessary to ensure the long-term preservation of paleontological resources at DENA while providing for the enjoyment and education of visitors, we author and aim to publish a new Paleontological Resources Management Plan (PRMP) for the park. The DENA Foundation Statement and other fundamental park publications already recognize paleontological resources as natural features of high value. Academic and public interest in the paleontological resources of DENA is growing, as are opportunities for research, discovery, and education. Where existing federal and state laws, regulations, policies, and guidelines only broadly address the management of paleontological resources on public lands, the DENA PRMP offers further detailed direction to DENA resource managers.

The DENA PRMP formalizes recommendations for paleontological resource inventory and monitoring, research oversight, museum collections and curation, and interpretation and education. Comprehensive and consistent management of paleontological resources at DENA will inform future stewardship decisions as climatic and societal changes manifest new environmental challenges. By facilitating investigation and interpretation of paleontological resources, the DENA PRMP will invite dialogue on climate change, environmental stability, and species survival within the National Park System and beyond.

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Technical Session 1: Sauropod & Ornithischian Dinosaurs (Wednesday, October 18, 2023, 8:00 AM)

## DESCRIPTION AND PHYLOGENETIC ANALYSIS OF A NEW TITANOSAURIAN SAUROPOD SPECIMEN FROM THE UPPER CRETACEOUS CERRO FORTALEZA FORMATION OF SOUTHERN PATAGONIA, ARGENTINA

Caputo, Cooper[1], Lamanna, Matthew[2], Ullmann, Paul[1], Casal, Gabriel[3], Ibiricu, Lucio[4], Lacovara, Kenneth[1]

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Because southern Patagonia remains sparsely explored from a paleontological standpoint, little is known of the Mesozoic continental vertebrate faunas of the region, including that preserved within the Upper Cretaceous (Campanian–Maastrichtian) Cerro Fortaleza Formation (CFF) of the Austral Basin of Argentina. Here we advance knowledge of the CFF dinosaur fauna by describing a new and associated sauropod specimen consisting of five caudal vertebrae and the proximal portion of a radius (specimen Museo Padre Molina [MPM]-PV 3282). Though the remains are fragmentary, they retain morphological information sufficient to determine the taxonomic affinities of the specimen. MPM-PV 3282 exhibits a combination of features not previously seen in a single sauropod individual, suggesting that it represents a taxon not previously recognized from the CFF. For example, the proximal radius of MPM-PV 3282 possesses a medially directed projection that has only been previously reported in the Australian mid-Cretaceous titanosauriform *Wintonotitan wattsi*. Similarly, the caudal vertebral centra of MPM-PV 3282 are square in lateral view, a feature otherwise seen in the basally branching Patagonian titanosaurian *Andesaurus delgadoi* and differing markedly from the much better known CFF titanosaurian *Dreadnoughtus schrani*. Finally, the caudal centra of MPM-PV 3282 exhibit two rough knobs protruding from the dorsal edge of the posterior face, a character previously considered an autapomorphy of the European titanosaurian *Lohuecotitan pandafilandi*. This combination of morphological evidence suggests that MPM-PV 3282 may represent a new titanosauriform species, but we refrain from making such a conclusion due to the highly incomplete nature of the remains. A maximum-parsimony phylogenetic analysis found MPM-PV 3282 to be an early diverging titanosaurian related to *Mnyamawamtuka moyowamki*a from Tanzania and *Atsinganosaurus velauciensis* from France.

**Funding Sources** Carnegie Museum of Natural History, Drexel University, Rowan University

Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**ELONGATED PELVIC BONE IN AN EOCENE THREE-TOOTH PUFFER (TETRAODONTIFORMES: TETRAODONTIDAE) SUGGESTS PRESENCE OF PELVIC FAN**

Carbi, Marina V.[1], Bemis, Katherine E.[2], Friedman, Matt[3], Bemis, William E.[1]

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The Three-tooth Puffer, *Triodon macropterus,* is the only extant member of the family Triodontidae, teleost clade Tetraodontiformes (pufferfishes and relatives). It has an unusually elongate and highly mobile pelvic bone that supports a large pelvic-fan used in defensive flaring behaviors. Extinct triodontids are represented by the Eocene species †*Triodon antiquus*. Initially known only from isolated dentitions from Belgium and France, CT scanning recently allowed study of more complete material from the London Clay Formation of southeastern England. The London Clay specimen includes an articulated skull and pelvic girdle. The morphology of the pelvic bone is similar to that of the extant species, *T. macropterus*, suggesting that extinct triodontids had a pelvic fan like that of its living relative.

**Funding Sources** We thank The Society of Vertebrate Paleontology and the SVP Futures Award for funding this project.

Technical Session 13: Fishes - Actinopterygians (Friday, October 20, 2023, 1:45 PM)

**DEEP KNOWLEDGE: INSIGHTS FROM THE POST-CRANIAL ENDOSKELETON OF *CHIRODUS GRANULOSUM***

Caron, Abigail[1], Coates, Michael[2]

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Deep bodies (i.e., rhombic, discoidal) are a distinctive and repeated motif of actinopterygian fishes; no commensurate examples are known in sarcopterygians, chondrichthyans, or outgroups. We identify as many as five separate origins of deep bodied actinopterygians in the Paleozoic alone. However, large-scale phylogenetic analyses fail to resolve convincing affinities of these clades and often lump them together, occasionally with younger groups of deep bodied fishes. This might be attributed to widespread homoplasies associated with a fusiform to deep body transformation, including coordinated changes to the skull shape, gape, dermal bones, scale forms, median and paired fins. Such convergences add noise to the already parlous state of early actinopterygian phylogeny. The diversification of actinopterygians in the aftermath of the end Devonian mass extinction is poorly understood, with the majority of available endoskeletal data restricted to small fusiform species. To address this problem, we present new post-cranial endoskeletal anatomy of *Chirodus granulosum,* the earliest known deeply rhombic actinopterygian, and discuss systematic implications and alternative approaches to building a deep body. Though all deep bodied fishes stretch the axial column dorsoventrally, we show that *Chirodus* accomplishes this in a distinct manner. In certain respects, the vertebral column resembles that of extant chondrosteans. However, it also displays features seen only in Devonian fishes such as *Mimipiscis*. Furthermore, structural supports for the median fins are also dissimilar to other well-characterized deep-bodied fishes. Notably, the pectoral fin is exquisitely preserved, and here, unexpectedly, we find characteristics shared with the Triassic chondrostean-aligned *Birgeria*. This detailed endoskeletal data not only provides insight into constraint and adaptation regarding the transitions to deep bodied forms but might also unveil cryptic evolutionary relationships of the deep bodied clades.

**Funding Sources** NSF (EAR) 2218892

Virtual Posters

**BADLANDS NATIONAL PARK: INTEGRATING SCIENTIFIC EDUCATION, OUTREACH, AND CITIZEN SCIENCE WITH**

**AN OPEN CONCEPT FOSSIL PREPARATION LAB**

Carpenter, Mary C.

Badlands National Park, Interior, South Dakota, United States

Badlands National Park (BADL) is home to one of the world's richest fossil mammal beds for the late Eocene and early Oligocene. Since the mid-1800s, BADL fossils have fascinated paleontologists and the public alike. These abundant fossil resources have put BADL in a unique position for paleontological research, with wide-scale public education and scientific outreach.

The Fossil Preparation Lab opened to the public in 2012 following the discovery of a *Hoplophoneus primaevus* skull just outside the Ben Reifel Visitor Center. The Fossil Preparation Lab has grown to become one of the largest interpretive programs in the park. Open May to October each year, the Fossil Preparation Lab has received over 581,000 visitors since 2012. Continuing to grow in popularity, in 2022 the Fossil Preparation Lab received 73,182 visitors – nearly one-third of all visitors to the Ben Reifel Visitor Center.

The Fossil Preparation Lab is a small space (22'x39'), borrowed from Resource Education's classroom. It is the only place in the Visitor Center where real fossils from the park are on exhibit for visitor education and enjoyment, and where Badlands fossils are prepared and conserved by Fossil Preparators. What makes BADL unique is that visitors can view all aspects of ongoing fossil preparation from start to finish just a table's width from the scientists. There are no glass walls limiting interactions between paleontologists and visitors. It is a truly open concept lab, enabling public viewing and interaction. Visitors talk to Fossil Preparators face-to-face, while watching them work mere inches away. All fossil preparation is done under microscopes that stream to monitors, allowing visitors to see what the preparator sees as they expose fossils.

The open concept lab allows park rangers and paleontologists to educate visitors about Citizen Science, resource stewardship and protection, and fossil conservation. As a result, visitors can directly contribute to fossil resource protection and paleontology by reporting fossil finds to rangers and paleontologists through the BADL Visitor Site Report (VSR) Program - the most successful Citizen Science Program offered by the park. Badlands Fossil Preparation Lab offers a unique opportunity for scientific outreach and education. Our program has proven to be very successful by including visitors in the scientific processes that support the NPS Mission of Citizen Science and Resource Stewardship and Protection.

**Funding Sources** Thank you to Badlands Natural History Association, Badlands National Park Conservancy, and countless visitors for their continued support of our Fossil Preparation Lab.

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Technical Session 16: Theropods - I (Saturday, October 21, 2023, 8:00 AM)

***DASPLETOSAURUS WILSONI* (THEROPODA, TYRANNOSAURIDAE) IS A SUBJECTIVE JUNIOR SYNONYM OF *D. TOROSUS*; *DASPLETOSAURUS* IS THE SISTER CLADE, NOT A PARAPHYLETIC GRADE, OF THE *TYRANNOSAURUS* LINE OF DESCENT**

Carr, Thomas[1], Brusatte, Stephen[2]

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The recent report of a new tyrannosaur, *Daspletosaurus wilsoni*, included the hypothesis of a paraphyletic *Daspletosaurus*. An examination of the inaugural article of *D. wilsoni* found issues with the diagnosis of *D. wilsoni*, *Daspletosaurus* and *D. horneri*; the stratigraphic distribution of *D.* spp.; and the phylogenetic analysis.

First, the autapomorphy of *D. wilsoni*, a shallow Rostral Mylohyoid Foramen (RMF) relative to the rostral process of the splenial, is based on a misunderstanding of the landmarks used to assess relative height. We found the height is the same as in *D. torosus* and *D. horneri*. Without an autapomorphy, "*D. wilsoni*" is a nomen dubium; the holotype (DBM 107) shares with *D. torosus* a wide second interdental plate of the maxilla, rostrally tapering maxillary fenestra, and a tall lacrimal horn with a distinct peak.

Second, a diagnostic character of *Daspletosaurus*, the Secondary Cornual Process (SCP) of the lacrimal, was thought by the authors as absent from the genus. However, the SCP is a distinct feature of the clade; this region of the bone is missing in the holotype specimen of "*D. wilsoni*," which might explain the erroneous interpretation.

Third, the authors recharacterized *D. horneri* based on a subadult (MOR 590): they claimed that the cornual process of the postorbital is short and not bipartite. However, the opposite conditions are seen in the adult specimen of *D. horneri* (MOR 1130). They also mischaracterized the direction of the prefrontal, which extends rostromedially, not mediolaterally – a direction not seen in any tyrannosaurid. They claim that the jugal shows a flexure – and hence a narrow snout as in *Tyrannosaurus rex* – but the flexure in the subadult is from damage.

Fourth, the authors present the stratigraphic distribution of *D.* spp. as points in geological time, but *D. torosus* (holotype + Dinosaur Park specimens) and *D. horneri* occupy extensive temporal ranges. In fact, the estimated geological age of "*D. wilsoni*" is within the range of *D. torosus*.

Fifth, the authors recover *Daspletosaurus* as a paraphyletic grade; we suspect that this resulted from recoding *D. horneri* based on subadult characters and damage. For example, a short postorbital horn is seen in adult *T. bataar* and *T. rex*, which presumably grouped *D. horneri* with those taxa.

In conclusion, we find that "*D. wilsoni*" is a junior subjective synonym of *D. torosus*, and a paraphyletic *Daspletosaurus* is a side effect of recoding *D. horneri* based on a damaged subadult specimen.

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Technical Session 19: Theropods - II (Saturday, October 21, 2023, 1:45 PM)

**NEW INFORMATION ON THEROPOD MATERIALS FROM THE LOWER CRETACEOUS ARUNDEL CLAY OF MARYLAND**

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The Lower Cretaceous Arundel Clay of Maryland has produced dinosaur fossils for more than a century. Its theropod fauna is currently thought to encompass *Acrocanthosaurus* (or a closely related form), one or more ornithomimosaurs, *Deinonychus* (or a closely related form), and one or more smaller taxa of uncertain affinities. Unfortunately, few specimens possess any species-level autapomorphies, and many assignments are based on morphological 'consistencies' with better-known taxa from coeval strata thousands of miles to the west. The limited Arundel Clay outcrops and the disarticulated nature of most materials has made it difficult to improve these identifications.

In contrast, USNM 466054 comprises associated materials from the axial and appendicular skeleton of a theropod dinosaur. Despite representing the most complete theropod (and possibly the most complete dinosaur) ever recovered from the Arundel Clay, it has received only scant attention since its 1992 discovery at the site of present-day Dinosaur Park in Laurel, Maryland. Recently the material has been further prepared and restudied, revealing important new details.

Anatomical and histological data indicate that USNM 466054 is a juvenile individual. Its more salient morphological features include: anteroposteriorly short dorsal vertebrae with tall, anteriorly inclined neural arches; closely associated greater and lesser trochanters of the femur; a pronounced anterior trochanter at the base of the lesser trochanter; and pedal unguals that lack expanded flanges along the medial and lateral edges of the ventral surface. These definitively exclude USNM 466054 from Ornithomimosauria and indicate it pertains to a more basal tetanuran. The presence of a medially tapering femoral head in dorsal view specifies assignment to *Acrocanthosaurus*.

The existence of *Acrocanthosaurus* in the Arundel Clay has been inferred based on isolated carcharodontosaurid teeth, but USNM 466054 offers the first robust evidence of the taxon's presence. This supports suggestions of continent-wide faunal similarities at the close of the Early Cretaceous, although not necessarily at the species level. Finally, this new identification of USNM 466054 casts doubt on the supposed ornithomimosaur affinities of many other Arundel Clay theropod specimens, in particular numerous isolated phalanges and unguals. The remainder of the Arundel Clay dinosaur fauna still requires close study and further revision.

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Technical Session 17: Afrotheria & Mammal Macroevolution (Saturday, October 21, 2023, 8:00 AM)

## IMPACTS OF PLEISTOCENE EXTINCTIONS ON LOCAL MAMMAL ASSEMBLAGES AROUND THE WORLD

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A large proportion of the world's megafaunal species went extinct during the late Quaternary, leading to dramatic reductions in community and ecosystem functioning. While the nature and severity of the extinctions is well documented on global and continental scales, less is known about local-scale impacts. We quantified the energy use and biomass of 203 pre-extinction and 290 post-extinction fossil assemblages from around the globe to determine effects on large mammal communities. Assemblage energy use was calculated from metabolic rates obtained for 518 individual species and was compared to species richness and indicators of taphonomy, archaeology, and biogeography. Globally, total biomass and energy use are greatly reduced in post-extinction assemblages. Human-accumulated assemblages are further homogenised post-extinction due to their high abundances of domesticated species. The presence of domesticates produces distinct relationships with species richness and variation in energy use across continents that differ considerably to pre-extinction patterns. This fundamental anthropogenic alteration of communities further exacerbated the impacts of Pleistocene extinctions, even in less severely impacted regions. The results show how human activities have altered mammalian communities for many thousands of years.

**Funding Sources** The study was funded through a Research Training Program Scholarship (no. 20213308) and a Discovery Project Award from the Australian Government (no. DP210101324).

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

## TAPHONOMY AND PRESERVATION BIAS OF MICROVERTEBRATE BODY FOSSILS AT THE REVUELTIAN HOMESTEAD SITE (UPPER TRIASSIC: NORIAN), GARITA CREEK FORMATION OF EAST-CENTRAL NEW MEXICO, USA

Carter, Caeden[1], Rose, Luke J.[1], Heckert, Andrew B.[1], Lauer, Bruce[2], Lauer, Rene[2]

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Triassic tetrapod assemblages document the transition from Paleozoic synapsid-dominated faunas to more “modern” Mesozoic ecosystems with a diversity of diapsids. However quantitative studies of Triassic microvertebrate assemblages (MVA) are few, so our understanding of biases in the Triassic tetrapod record is limited. The Homestead (HS) site collection, from the Upper Triassic Garita Creek Formation of east-central New Mexico, consists of thousands of teeth, bones, scales, and coprolites, most of microvertebrate (<1cm) size. This is a relatively rare Revueltian (Norian) age microvertebrate locality and thus has unique potential to illuminate patterns of tetrapod evolution in the Late Triassic. Fossils from Homestead were collected both in situ and from the weathered slope immediately below the site. As received, the collection consisted of “picked bags” of identifiable, but unsorted fossils and ~25 kg of unconsolidated “concentrate” from which the picked bags were originally culled. Previously we reanalyzed the concentrate, determining that coprolites are much more common than the picked collections would indicate. So, we ignored coprolites for this study to assess the frequency of occurrence of body fossils. For this study, we counted hundreds of unsorted fossils from the “picked bags” to assess possible bias. We sorted each bag into >4 mm, >2 mm, and >1 mm fractions. Student volunteers (Finding Fossils on Friday, or FFF) sorted and identified all fossils as bones, teeth, or scales. Six bags have been sorted, labeled, and counted with a total sample size of 2347 fossils. Overall, the picked bags consist of 24% bone fragments, 75% teeth/tooth fragments, and 1% scales, with all scales in the smallest size fraction. When broken down by size, however, we see a clear trend that larger fragments are more likely to be bone (46/30/8% of 4, 2, and 1 mm collection), with tooth fragments having a higher yield at the smaller sizes, specifically 54/70/92% of 4, 2, and 1 mm. When examining individual bags, the percentages vary widely from 9-35% bone fragments and 65-89% teeth. Combined results show a clear bias towards teeth, especially in the 1 mm fraction, probably reflecting that even tiny teeth remain diagnostic whereas few small bones or bone fragments are as identifiable. Preliminary taxonomic assignments indicate that, unsurprisingly, the site

yields primarily semiaquatic taxa, a hypothesis we will evaluate with the data gathered here.

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**FIRST UPPER MOLAR OF THE LATEST OLIGOCENE PLATYPUS *OBDURODON INSIGNIS* CASTS LIGHT ON DENTAL EVOLUTION IN THE ORNITHORHYCHIDAE (MONOTREMATA).**

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Monotremes, the only extant egg-laying mammals, are represented today by one species of platypus (Ornithorhynchidae) and four of echidna (Tachyglossidae). Fossil monotremes are uncommon, less than a dozen species ranging from early Aptian (126 Ma) to late Miocene (5 Ma). Most fossil taxa are based on isolated teeth or incomplete jaws, with only four species having upper molars.

Here we describe a platypus left M2 from Mammalon Hill (Ngama l.f; Faunal Zone D) of the upper Oligocene Etadunna Fm., Lake Palankarinna, South Australia. The well-preserved specimen (South Australian Museum [SAM] P24262), previously identified as *Obdurodon* sp., is from the same formation and general area as the holotypic m1 of *Obdurodon insignis* (Ditjimanka l.f.; Zone B). The paratypic m2 of *O. insignis* is from the Namba Fm.

The holotypic *O. insignis* m1 matches the newly referred M2 (SAM P24262) in size, such that the m1 apices fit within the loph basins of the M2. Moreover, the distance between the lophids of the paratypic m2 matches the distance between the lophs of the M2. Thus, the M2 and the m1 and m2 are in the same size range for occlusion and can be assigned to *O. insignis*.

The holotypic m1 and paratypic m2 of *O. insignis* come from sites 250 km apart, whereas the m1 and the new M2 are temporally separated by 450 Ka in the Etadunna Fm. *O. insignis* is therefore the only known platypus species in the region and from the latest Oligocene.

Ornithorhynchidae is diagnosed by a reduced molar number (two per quadrant) and molars with shallow roots. We add to this list the following: (1) molars with multiple roots (M1/m1 = six roots; M2/m2 = four roots) and upper molars with (2) ectoflexus between parastyle and stylocone; (3) metaloph with ectoflexus between metastyle and postmetastyle; (4) wide mesial cingulum across anterobuccal surface; and (5) paraloph wider than metaloph. The *O. insignis* upper molar shares apomorphies with that of *Monotrematum sudamericanum* from the Early Paleocene (63.5 Ma) of Argentina, indicating that *Monotrematum* is also an ornithorhynchid.

The close relationship of *Obdurodon* and *Monotrematum* and the temporal occurrence of the latter indicates that the platypus/echidna divergence, occurred no later than Early Paleocene. This is consistent with recent phylogenomic estimates that place this divergence at or prior to 55 Ma. Our hypothesis on dental evolution in ornithorhynchids assumes that there has been a separate dental history within the Tachyglossidae.

**Funding Sources** JAC research supported by US National Science Foundation grant ANT-0003844. MCL research participation supported by US National Science Foundation grant ANT-1142129.

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Technical Session 4: Dinosaur Soft Tissues (Wednesday, October 18, 2023, 1:45 PM)

**THE HADROSAUR POSTORBITAL "POCKET" AND THE EVOLUTION OF EXTRARENAL SALT-EXCRETION IN REPTILIA**

Cerio, Donald G.[1], Bever, Gabriel S.[1], Witmer, Lawrence M.[2]

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Osmoregulation is a critical feature of tetrapod physiology. Whereas the kidneys of crown mammals are efficient at eliminating excess salt, the general inability of the reptile kidney to produce hyperosmotic urine leaves this clade reliant on extrarenal organs. Extant reptiles exhibit a diverse anatomical array of extrarenal solutions, such as the nasal gland in squamates and birds, lingual gland in crocodylians, and lacrimal gland in sea turtles. We considered the extraordinary postorbital “pocket” of *Edmontosaurus* within the context of this broader problem. Other hadrosaurs (e.g., *Kritosaurus*, *Corythosaurus*) have subtle postorbital fossae, but in *Edmontosaurus* the recess expands into a large chamber that opens broadly into the orbit. The morphofunctional role of this pocket has long been questioned, with arguably the most popular hypothesis being that it housed the nasal gland. We set out to test this hypothesis formally by considering all plausible pocket occupants—among them glands, vasculature, muscles, and pneumatic sinuses—using a diversity of anatomical approaches, including contrast-enhancing workflows for CT scanning and an Extant Phylogenetic Bracket.

Our analysis identifies the lacrimal gland, not the nasal gland, as the likeliest occupant of the postorbital pocket, alongside associated blood vessels and supporting connective tissues. The lacrimal gland of extant reptiles (including birds) consistently occupies this same caudodorsolateral region of the orbit. The extraordinary size of the bony pocket in *Edmontosaurus*, however, suggests that these tissues were apomorphically enlarged, although where this apomorphy originated on the reptile tree is unclear. Lacrimal glands are also enlarged in crown turtles, and in sea turtles the gland excretes salt. These shared enlargements may be homologous and thus plesiomorphic within Archelosauria, but, given the long branch lengths separating these clades, independent origin of hypertrophy is likely. Given our findings, a reappraisal of the evolutionary history of reptilian cephalic glands—and the selective pressures and developmental mechanisms of their enlargement—is warranted. In *Edmontosaurus*, lacrimal gland hypertrophy was perhaps driven (1) by terrestrial herbivorous diets, which impose salt loads with different ions than marine animals experience, or (2) by airway expansion, of which hadrosaurs are exemplars and to which lacrimal gland secretions could plausibly have contributed humidification.

**Funding Sources** DGC—Jurassic Foundation; GSB—NSF DEB-1947025; LMW—NSF IOB-0517257, IOS-1050154, IOS-1456503; SRC 2021-02973

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Virtual Posters

**UNCOVERING DINOSAUR DEATH POSE: UTILIZING QUANTITATIVE AND QUALITATIVE METHODS TO ANALYZE THE DRIVERS OF OPISTOTHONIC DEATH POSTURE IN DINOSAURS**

Chapa, Leila, Chapa, Paloma, Nourie, Andreana, Wolff, Ewan, Moore, Jason R.

Honors College, University of New Mexico, Albuquerque, New Mexico, United States

For over a century the drivers of dinosaur death pose have remained controversial. Described from a number of exquisitely preserved dinosaur specimens, the “opisthotonic pose” is characterized by the backward contortion of the neck and tail towards the center of the body. Geologist Roy Lee Moodie first identified this posture in 1918 and ascribed it to a neurological or nervous system malfunction amidst the animal’s death throes. However, subsequent research has argued against this interpretation. In the 104 years since Moodie’s publication, the opisthotonic posture has been linked to different drivers of death pose including anatomical, environmental, and pathological.

Here we attempt to differentiate among these drivers using a combination of qualitative and quantitative approaches. We have gathered a dataset of 100+ images of articulated fossil specimens from across the family tree of dinosaurs, collected without emphasis on a particular death pose. Utilizing observational data from all of these specimens as well as a quantitative image analysis, we assessed the distribution of opisthotonus across the dinosaur family tree. Opisthotonus was common among large non-avian theropods (47% of specimens), but much rarer outside of this group (2%).

Examining death poses of modern taxa, we were able to falsify gross anatomy (long neck, long tail, presence of a strong nuchal ligament), many taphonomic causes, and some phylogenetic hypotheses (the opisthotonic posture is a theropod feature) as drivers of this death pose. It appears that opisthotonus is predominantly a non-avian theropod trait, and so phylogenetically constrained drivers (taxon-specific anatomy, pathology) should be considered for its interpretation.

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Symposium Session: Theropod Flight Origins (Thursday, October 19, 2023, 1:45 PM)

## BIRDS, BONES, AND BASIC BIOLOGY: IDENTIFYING ISSUES OF INTEGRATION

Chase, Hila Tzipora

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To understand the evolution of avian flight it is necessary to resolve the functional morphology of the flight stroke. It is also necessary, however, to resolve many other functional, ecological, and evolutionary gaps in our understanding of basic avian biology- especially as it pertains to osteology, fossil analysis, and integration of these approaches across the many statistical and modelling-based methods commonly used in paleontology. Only then can results from in-depth analysis of functional morphology and other direct biological signals in both extant and extinct taxa be interpreted relevantly and provide testable hypotheses and robust answers in the context of theropod flight origins. In seeking to investigate the functional morphology of the flight stroke across a phylogenetic sample of extant birds (51sp.), these issues became apparent in two distinct ways. The first is a lack of basic developmental and osteological research in extant avian systems, where much is assumed from mammals as well as "just-so" stories about bird osteology and aeromechanics, all of which is (understandably) taken for granted by paleontologists and engineers alike. The second issue is an overall barrier identified across paleontology in terms of specific statistical approaches and tests used by various studies that are not possible to directly integrate at an analytical level. To assuage the first issue, integrative studies were conducted to investigate functional morphology and ontogeny in the avian humerus and femur. We identified several novel discoveries, including functional patterns in holistic analysis of both trabecular and cortical bone as it pertains to the ontogeny, biomechanics, and ecological context of a powered flight stroke. To tackle the second issue, we present specific examples of areas in which methodological and statistical "issues of integration" can be met with focus on biological signals that can be analyzed using fossils in conjunction with modelling and large-scale phylogenetic studies. Our goal is to showcase specific examples of not only *where* our current gaps in knowledge lay, but a hands-on approach toward *filling* these gaps at a community-level: Where genuine integration across methodologies can be performed toward gaining insight into the evolution of powered flight in the theropod lineage, regardless of the barriers caused by our systemically defined fields, countries, and reliance on often-lacking extant avian biology.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

## HOW ROUGH? ASSESSING THE UTILITY OF BONE SURFACE MICROTEXTURE AS A CORRELATE FOR PNEUMATIC DIVERTICULA.

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Among extant vertebrates, pneumatic (i.e., air-filled) invasions of the postcranial skeleton are unique to birds. This phenomenon, called postcranial skeletal pneumaticity (PSP), results from pneumatic diverticula (PD) that emerge from the lung and associated air sacs and invade portions of the axial and appendicular skeleton. Paleontologists have long been interested in identifying osteological correlates of PD in birds and their extinct relatives as a means of reconstructing the evolution of PD and associated pulmonary tissues. Proposed correlates include fossae, foramina, and a smooth or crenulated bone surface texture. At present, however, the only unambiguous osteological correlate of PD is a foramen that opens up into a large internal chamber. All other osteological correlates of PD are ambiguous, as they can also be associated with other soft tissues (e.g., vasculature; muscle; fat). Tracing the origins of the pulmonary soft tissues that give rise to PSP in the fossil record has thus proven problematic, because the earliest evidence for PD is limited to ambiguous fossae.

Although previous authors have cast doubt on the utility of gross bone texture as a correlate of PD, soft tissues like muscles and ligaments leave histological impressions on bone at both macro- and microscopic scales. Thus, it remains possible that evidence for PD-bone interaction exists in bone surface microtexture. Using an S Neox Optical Profiler, we apply surface metrology to a sample of bones from birds and other reptiles to quantitatively classify microtextural signatures of different soft tissues: muscle, cartilage, fat, and pneumatic epithelium. Preliminary results from *Pelecanus* show marked differences in surface texture for each tissue type. Pneumatic epithelia are associated with subparallel striations, areas of muscle attachment have a jagged, high-relief texture, and articular facets exhibit a distinct, ‘hoodoo’-like texture that reflects the interface between bone and articular cartilage. Ongoing work is expanding the sample to include both pneumatic (e.g., *Buteo jamaicensis*; *Branta canadensis*) and non-pneumatic (e.g., *Alligator mississippiensis*) taxa. Ultimately, our growing dataset will be used to assess the extent to which microsurface textures related to different soft tissues can be statistically differentiated, and hence whether the presence of PD can be recognized in fossil taxa (e.g., Tawa) lacking unambiguous evidence of PSP.

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Technical Session 7: Birds (Thursday, October 19, 2023, 8:00 AM)

**RAMPANT HOMOPLASY IN THE PECTORAL GIRDLE AND FORELIMB SKELETON OF CROWN BIRDS: IMPLICATIONS FOR MORPHOLOGICAL PHYLOGENETICS AND SYSTEMATIC PLACEMENT OF AVIAN FOSSILS**

Chen, Albert[1], Steell, Elizabeth[1], Benson, Roger[2], Field, Daniel J.[1]

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The avian pectoral girdle and forelimb apparatus has long been a subject of macroevolutionary research, particularly for understanding the evolution of avian flight. It is widely recognized that the skeletal morphology of this anatomical region is strongly correlated with avian locomotor mode and ecology, which may be a potential driver of phenotypic convergence related to incongruities between recent molecular and morphological phylogenetic analyses of crown-group birds. This convergence might hamper our ability to accurately assign isolated pectoral elements (which are commonly found as avian fossils) and determine the affinities of extinct bird taxa. However, the impact of homoplasy in the avian pectoral girdle and forelimb apparatus on phylogenetic analyses has not been previously assessed in detail across a representative sample of crown birds.

To evaluate the interplay between phylogeny and morphological variation in the avian pectoral girdle and forelimb skeleton, we assembled a novel dataset of 204 discrete characters from this anatomical region for a phylogenetically diverse range of 75 extant bird species and two crownward stem-birds. Unconstrained phylogenetic analyses, qualitative anatomical comparisons, and quantitative metrics of homoplasy all highlight the fact that similar morphologies in pectoral girdle and forelimb elements have evolved repeatedly in distantly related groups of birds, supporting rampant homoplasy in this region as a confounding factor in avian morphological phylogenetics. Furthermore, our analyses indicate that extant tinamous and galliforms, two groups of birds often used as models for early crown birds, do not closely resemble crownward stem-birds in their overall pectoral girdle and forelimb osteology, and that inferences about the ancestral morphology of crown birds based solely on extant species may be misled as a result. Nonetheless, analyses implementing a molecular scaffold permit the identification of plausible diagnostic character combinations for many avian clades previously only recovered using molecular data. Although large morphological datasets may not guarantee increased congruence with molecular phylogenetic studies, they can nonetheless be valuable tools for identifying anatomical synapomorphies of key clades, placing fossils into phylogenetic context, and studying macroevolutionary patterns within major groups of organisms.

**Funding Sources** This work was supported by a UKRI Future Leaders Fellowship and the Isaac Newton Trust (DJF), and a Paleontological Society Student Research Award (AC).

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Technical Session 17: Afrotheria & Mammal Macroevolution (Saturday, October 21, 2023, 8:00 AM)

**PIONEERING PROBOSCIDEAN PALEOENDOCRINOLOGY: HORMONES IN TUSKS SHED LIGHT ON WOOLLY MAMMOTH MATING BEHAVIOR**

Cherney, Michael D.[1], Fisher, Daniel C.[2], Auchus, Richard[1], Rountrey, Adam N.[2], Shirley, Ethan A.[2], Selcer, Perrin[3], Mol, Dick[4], Boeskorov, Gennady[5], Vartanyan, Sergey[6], Tikhonov, Alexei[7]

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Steroid hormones incorporated into continuously growing tissues provide a record of endocrine activity during the life of an animal. Numerous studies have reported steroid concentrations in hair, nails, and other proteinaceous materials comprising cumulative records of circulating concentrations averaged over various time intervals. Recent reports of steroid hormones in mineralized tissues preserved over long time spans, even thousands of years, make this avenue of inquiry a potentially valuable tool in paleontological studies. Using liquid chromatography with tandem mass spectrometry (LC-MS/MS) we measured steroid hormone concentrations in proboscidean tusks. Initial results reveal testosterone, progesterone, androstenedione, cortisol, and trace amounts of other steroids preserved in both modern and late Pleistocene tusk dentin. Serial analyses of a tusk from a bull African elephant reveal changes consistent with musth occurring annually in its last years of life. Comparable data from the mammoth tusks provide evidence that mature bull mammoths also experienced musth and that it was similar to African elephant musth in duration, intensity, and periodicity. These results provide insights into the paleobiology of mammoths and provide a tool for characterizing spatio-temporal variations in woolly mammoth musth that could be used to investigate population dynamics and impacts of environmental stress. Furthermore, they demonstrate the utility of dentin for wide-ranging studies of hormones in paleontology, zoology, ecology, and wildlife conservation to investigate development, reproduction, behavior, and stress in modern and extinct mammals.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**QUANTIFYING PURGATORIID PLESIADAPIFORM DENTAL VARIATION AND DOCUMENTING SPECIES RICHNESS IN THE MIDDLE TULLOCK MEMBER, FORT UNION FORMATION, NORTHEASTERN MONTANA**

Chester, Stephen G.[1], Crowell, Jordan W.[2], Mahadevan, Nidhi[1], Hovatter, Brody T.[3], Wilson Mantilla, Gregory[3]

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The purgatoriid *Purgatorius* is the geologically oldest known plesiadapiform and has long been thought to lie near the origin of all primates. Results of many phylogenetic analyses corroborate this hypothesis by supporting *Purgatorius* as the most basal stem primate or a basally divergent stem primatomorphan. Purgatoriid morphology thus is crucial to establishing character-state polarity in phylogenetic analyses focused on resolving the broader relationships of plesiadapiforms and crown primates. Recently described fossils and species of purgatoriids have added to this picture, but quantitative assessments of intraspecific variability and species validity are lacking, in part because some species are known only from a few specimens. Here we use µCT scanning technology and three-dimensional geometric morphometrics (3DGM) to quantify intra- and interspecific dental variation of *Purgatorius* as a first step in evaluating existing alpha taxonomy. Our sample includes specimens from the largest collection of purgatoriid fossils known (>1,500), which were recovered from the early Paleocene (Pu3 interval zone of the Puercan North American land mammal 'age') localities in the middle of the Tullock Member, Fort Union Formation, Garfield County, northeastern Montana. We examined all known dentaries of *P. janisae* and collected 20 repeatable landmarks including cusp apices and intersections between crests on unworn first and second lower molars. Principal component analysis results distinguish first and second lower molars of *P. janisae* along PC1 related to differences such as protoconid height, distance between the protoconid and metaconid, trigonid length, and maximum crown width. First and second lower molars can also be distinguished in our 3DGM results when additional purgatoriid species from other geographic regions in western North America are included, which has aided in recognizing previously misidentified isolated

lower molar loci and may have a bearing on purgatoriid species diagnoses. 3DGM analyses incorporating larger samples of isolated purgatoriid teeth from Pu3 of northeastern Montana have also assisted in documenting a greater diversity of plesiadapiform taxa from this study area than previously recognized, including at least four species of *Purgatorius* (*P. janisae*, *P. unio*, *P. mckeeveri*, *Purgatorius* cf. *P. pinecreeensis*), which adds to our understanding of plesiadapiform species richness and biogeography within the first million years of the Cenozoic.

**Funding Sources** This study was funded by a Leakey Foundation Research Grant, a PSC CUNY Award, City University of New York, and the Myhrvold and Havranek Charitable Family Fund.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

## CHARACTERIZING TRANSPORT IN HADROSAUROID DINOSAURS: AN ACTUALISTIC EXPERIMENTAL APPROACH TO FLUVIAL TAPHONOMY

Chiappone, Michael A.[1], Guala, Michele[2], Rogers, Raymond[3], Makovicky, Peter[1]

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Taphonomic processes create bias in the fossil record, and understanding these processes is integral to interpreting the record of extinct life worldwide. Bones preserved in fluvial environments make up a substantial part of the vertebrate fossil record. These bones have often been transported varying distances from the location of death before becoming buried. Experiments in flumes and natural settings have explored the fluvial taphonomy of mammal skeletons, but the taphonomy of other terrestrial vertebrates, especially extinct clades, has only been sparingly studied directly. Hadrosauroids are a dinosaur clade known from extensive remains throughout the Cretaceous and across the globe, making them an ideal group for taphonomic study. Previous examinations regarding the fluvial taphonomy of their skeletons have often applied bone transport groups derived from classic studies on mammals. Some researchers have raised concerns that the morphologies of non-mammalian bones would not exhibit the same hydraulic properties as mammals, producing different transport patterns. Here, we investigate hadrosauroid bone transport under various flow conditions through actualistic flume experiments using 3d printed models with comparable densities to real bone. We aimed to characterize the timing of transport of different elements (Voorhies Groups), orientation of bones relative to flow direction, and bone surface abrasion patterns. Some elements behave similarly to those described in mammals. As would be expected from previous work, relatively heavy bones such as the femur tend to move last, acting as lag elements. Lighter elements such as the scapula and radius tended to begin moving at much lower flow speeds. Because dinosaur pelvic bones are not fused as in mammals, we observed that the isolated pubis is often among the first elements to commence movement, often rotating or sliding along the bed. Cylindrical limb bones tend to roll or slide along the bed, orienting to be parallel to flow faster or slower depending on element size and flow velocity. Bones with more complex shapes, such as the curved and concave blade of the scapula, moved in less straightforward and unique ways, even vaulting over other bones. We also found that burial by fine silt and mud could be achieved relatively quickly even at slower flow speeds, and burial by sand played an important part in inhibiting transport in higher flow regimes.

**Funding Sources** This research was partially funded by National Science Foundation award FRES 1925884.

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Technical Session 1: Sauropod & Ornithischian Dinosaurs (Wednesday, October 18, 2023, 8:00 AM)

## THE OLDEST PACHYCEPHALOSAUR (ORNITHISCHIA: MARGINOCEPHALIA) FROM THE LOWER CRETACEOUS HUHTEEG FORMATION AT KHUREN DUKH LOCALITY IN SOUTHEASTERN MONGOLIA

Chinzorig, Tsogtbaatar[1], Takasaki, Ryuji[2], Yoshida, Junki[3], Buyantegsh, Batsaikhan[4], Mainbayar, Buuvei[5], Tucker, Ryan[6], Tsogtbaatar, Khishigjav[5], Zanno, Lindsay E.[7]

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Pachycephalosaurians are small- to medium-bodied, bipedal ornithischian dinosaurs that inhabited Cretaceous ecosystems of Asia and North America. They are characterized by a thickened skull roof formed by inflated frontoparietal and enlarged peripheral elements and reduced forelimbs relative to the hind limbs. Despite an increasing fossil record, our knowledge of pachycephalosaurian dinosaurs largely stems from cranial elements (e.g., frontoparietal bones). To date, only seven taxa preserve the postcranial skeleton (*Goyocephale*, *Homalocephale*, *Pachycephalosaurus*, *Prenocephale*, *Stegoceras*, *Stygimoloch*, and *Wannanosaurus*). Currently, the definitive record of pachycephalosaurians is restricted to the Late Cretaceous (Campano-Maastrichtian), which obfuscates the origin and early evolution of this unique clade. Here we report the oldest pachycephalosaurian specimen from the Lower Cretaceous Albian-aged Huhteeg Formation at the Khuren Dukh locality in southeastern Mongolia. As in other pachycephalosaurians, the premaxilla bears three teeth with an enlarged, "canine-like", crown in the posteriormost position. Despite its geologically oldest occurrence, the new pachycephalosaurian bears a fully developed dome as in Late Cretaceous taxa. It also exhibits some traits plesiomorphic for Marginocephalia such as an anteroposteriorly compressed parietosquamosal shelf and the absence of the nodes on the posterior surface of the parietosquamosal. The new specimen also exhibits basal ornithischian characters including long and slender hind limb elements. A combination of paleohistological data and an externally evident frontoparietal suture and open neurocentral sutures indicate that the individual was skeletally immature at the time of death. A newly compiled phylogenetic analysis from recent ornithischian and pachycephalosaurian matrices recovers the new taxon as the earliest diverging pachycephalosaurian, congruent with its earliest geological occurrence. It also demonstrates that a frontoparietal dome evolved early in the evolution of pachycephalosaurians and that the flat-headed condition was likely a secondarily acquired feature. Furthermore, it provides key insight into broader ornithischian phylogenetic relationships, supporting a sister-relationship between Pachycephalosauria and Ceratopsia, which is not universally accepted, by filling the morphological gap between the two clades.

**Funding Sources** 2021 PS - Arthur J Boucot Research Grant to TC; 2022 AMNH - Collection Study Visiting Researcher Grant to TC; 2023 NGS - Research & Exploration grant to LZ, TC, RT, JY, & KT

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Technical Session 19: Theropods - II (Saturday, October 21, 2023, 1:45 PM)

## THE NORTHERNMOST OCCURRENCE OF A DEINOCHEIRID ORNITHOMIMOSAUR FROM MONTANA (UPPER CRETACEOUS, JUDITH RIVER FORMATION): ITS PALEOBIOGEOGRAPHIC AND BIODIVERSITY SIGNIFICANCE

Kobayashi, Yoshitsugu[1], Chinzorig, Tsogtbaatar[2], Takasaki, Ryuji[3], Fiorillo, Anthony[4], Chiba, Kentaro[5], Saneyoshi, Mototaka[5], Ishigaki, Shinobu[5]

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Ornithomimosauria is a clade of maniraptoriforms that are edentulous in derived taxa and flourished during the Late Cretaceous in the Northern Hemisphere. Edentulous taxa form at least two clades: Ornithomimidae and Deinocheiridae. While members of Ornithomimidae are medium to large in body size, highly specialized in cursoriality that were diversified and rich in both Asia and North America, members of Deinocheiridae, exemplified by the gigantic *Deinocheirus mirificus* from Mongolia, are less cursorial and were recognized only in Asia until the recent discovery of *Paraxenisaurus* from Mexico. Here we report a pair of nearly complete edentulous dentaries, discovered from a *Corythosaurus* quarry of the late Campanian Coal Ridge Member of the Judith River Formation, northern Montana, approximately 30 km southeast to the type section of the Judith River Formation. As in other edentulous ornithomimosaurs, it has a dorsolaterally facing, well-developed cutting edge anteriorly, occupies more than one-third of the preserved length, and a

mediolaterally thickened dorsal rim posteriorly throughout its length. The dentaries are dorsoventrally high and massive. The maximum height reaches as much as 40% of the length from the anterior tip to the estimated anterior margin of the external mandibular fenestra, similar to *Deinocheirus mirificus*. Additionally, this specimen shows a significant symphysial expansion, an anteroposteriorly long Meckelian groove, and a convex dorsal outline of the cutting edge with the anteriorly downturned dentaries. The combination of these characters suggests that this material belongs to Deinocheiridae. This is the first record of the family from the northern North American continent, extending the biogeographic range of the group approximately ~3,000 km northward. Along with the occurrence of the Asian ornithomimid *Qiupalong* from the Belly River Group of Alberta (penecontemporaneous to the Judith River Formation), the new material suggests more active inter-continental faunal exchange of ornithomimosaurs between Asia and North America during the Late Cretaceous than previously suggested. The material discussed here not only adds further details to the biogeography of North American ornithomimosaurs but also illustrates potential for understanding dinosaur diversity even within one of the world's best sampled dinosaur-bearing rock sequences.

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Symposium Session: Theropod Flight Origins (Thursday, October 19, 2023, 1:45 PM)

### NEW INFORMATION ON THE STRUCTURE OF THE HINDWING SHEDS LIGHT ON FLIGHT PERFORMANCE OF *MICRORAPTOR* (THEROPODA: DROMAEOSAURIDAE)

Chotard, Matthieu[1], Kaye, Thomas G.[2], Grosmougin, Maxime[1], Barlow, Luke A.[1], Xiaoli, Wang[3], Zheng, Xiaoting[4], Pittman, Michael[1]

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Previously, studies of the *Microraptor* hindwing were mostly based on the longest feathers linked with the metatarsus and tibiotarsus, other feathers were mostly poorly preserved on specimens of interest. Laser-Stimulated Fluorescence (LSF) of new and previously described *Microraptor* specimens reveals new plumage features and refines the hindwing shape of this four-winged dinosaur. Preserved soft tissues revealed by LSF on the 8 new specimens provide elusive clues to depict the anatomy of the hindlimb muscles. The general shape of the hindwing is exclusive to *Microraptor* and can be divided in two parts. Firstly, primary metatarsal remiges are arranged in an isosceles triangle shape with an outward curvature on the medial side and a straighter lateral side. Secondly, there is an inward curvature displayed by the tibiotarsal feathers that forms a continuous shape with the outwardly curved primary metatarsal coverts. The main new feature described in the hindwing feathers are the asymmetrically vaned major primary coverts that support an aerodynamic function. Furthermore, smaller feathers are here described for the first time along the whole hindlimb. Situated at the base of the lesser trochanter, the femoral accessory trochanteric crest implies constraints on muscles of the *pubo-ischio-femoralis internus 2* group, which associated with a hindlimb:trunk ratio closer to that of modern running birds, suggests an important locomotor role of the hindlimbs for both flying and walking. By making comparison between the new and old specimens, with other iconic early paravians such as *Archaeopteryx* and *Anchiornis* as well as with modern birds, the new data imply that the hindwing of *Microraptor* had an important role in its flight and is consistent with non-strictly arboreal behavior.

**Funding Sources** RGC General Research Fund (17120920; 17105221)

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

### CHONDRICHTHYAN FAUNA OF THE CARBONIFEROUS-PERMIAN BOUNDARY (COUNCIL GROVE GROUP, RED EAGLE LIMESTONE) OF KANSAS

Ciampaglio, Chuck[1], Cline, Daniel A.[1], Shell, Ryan[2], Fuelling, Lauren[1]

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The Glenrock Limestone and Bennett Shale members of the Red Eagle Limestone at the Tuttle Creek Lake Spillway near Manhattan, Kansas represent the boundary between the Carboniferous and Permian Periods within North America. Fusulinids and brachiopods are found throughout the Red Eagle Limestone, but fossils of chondrichthyans and osteichthyans have only been reported from the Bennett Shale. This investigation reports on the first appearance of marine vertebrates from the Pennsylvanian Glenrock Limestone, as well as taxa recovered from the Permian Bennett Shale. Most of the taxa extracted from the dissolved residue of the Glenrock Limestone are also found in the Bennett Shale except for a specimen of Protacrodontidae indet. Taxa that endured across the Carboniferous-Permian boundary include symmoriiform chondrichthyans (*Stethacanthus*, *Denaea*), ctenacanthiform chondrichthyans (*Glikmanius myachkovensis*), Euselachians (*Cooleyella* sp.), and palaeonisciform osteichthyans (Palaeonisciformes indet.). Additional taxa recovered from the Bennett Shale include bransonelliform chondrichthyans (*Bransonella nebraskensis*), phoebodontiform chondrichthyans (*Adamantina benedictae*, Jalodontidae indet.), and eugeneodontiform chondrichthyans (*Bobbodus schaefferi*).

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Technical Session 19: Theropods - II (Saturday, October 21, 2023, 1:45 PM)

## COMPARATIVE NEUROANATOMY OF “MID CRETACEOUS” APEX PREDATORY DINOSAURS OF AFRICA SUPPORTS NICHE PARTITION

Ciudad Real Ballestero, María[1], Vidal, Daniel[2], Sereno, Paul C.[2]

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A triumvirate of large-bodied theropod dinosaurs are commonly present in Cretaceous faunas across northern and central Africa. During the early Late Cretaceous (Cenomanian), the allosauroid *Carcharodontosaurus*, spinosaurid *Spinosaurus*, and an abelisaurid have been found as contemporaries in the Kem Kem Group in Morocco and in the Echkar Formation in Niger. The first two genera are better represented and thought to have occupied distinctive ecologic niches: a fully terrestrial predator for *Carcharodontosaurus* and a semiaquatic shoreline piscivore for *Spinosaurus*.

We use CT scans of individual skull roof bones and braincases of *Carcharodontosaurus* and *Spinosaurus* from Morocco and Niger to compare their endocranial and inner ear morphology. Differences in these regions may be related to their divergent feeding behaviors. The olfactory bulbs are noticeable less developed in *Spinosaurus* and its older relatives *Irritator* and *Suchomimus* than in species of *Carcharodontosaurus* or its relatives *Giganotosaurus and Allosaurus*. In spinosaurids, the olfactory bulbs are shorter and narrower mediolaterally. The optic lobes, in contrast, appear to be relatively larger in both *Irritator* and *Suchomimus* than in *Carcharodontosaurus* and relatives. Larger olfactory and optic bulbs are known to correlate with greater olfactory and visual acuity, suggesting that spinosaurids emphasized sight whereas carcharodontosaurids relied more on smell during predation. The semicircular canals of the inner ear in *Spinosaurus* have a narrower canal diameter and smaller arc than in earlier relatives, *Suchomimus* and *Irritator*, and in *Carcharodontosaurus.* The inclination of the snout relative to the lateral semicircular canal reveals a staged increase in the downward deflection of the snout. In *Carcharodontosaurus* the snout angles downward at ~16 degrees, which seems to be the basal condition in large-skulled tetanuran theropods. In *Suchomimus* that angle doubles to ~33 degrees and reaches ~46 degrees in *Spinosaurus* and *Irritator*. These derived spinosaurines, thus, interpreted to have spent more of their time feeding in shallow waters procuring prey near ground level and may have benefited from a less obstructed frontal view than in less piscivorous or terrestrial predators.

**Funding Sources** DV is a Marie Sklodowska-Curie Global Action fellow (HORIZON-MSCA-2021-PF grant; Project Ref. 101068861 — EvoSaurAf).

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Technical Session 7: Birds (Thursday, October 19, 2023, 8:00 AM)

## FIRST EDENTULOUS ENANTIORNITHINE FROM THE JEHOL AVIFAUNA BIOTA

Clark, Alexander[1], O'Connor, Jingmai[2], Xiaoli, Wang[3], Zhang, Xiangyu[4], Wang, Xing[3], Zheng, Xiaoting[3], Zhou, Zhonghe[5]

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Among known Mesozoic birds, enantiornithines exhibit the greatest morphological diversity, which likely underpins their species diversity, range, and overall success throughout the Cretaceous. The majority of enantiornithines are known from the ~130-120 Ma Jehol Biota in northeastern China. Aspects of enantiornithine anatomy that do not differ drastically from neornithines have been used for morphology-based predictions regarding behavior and diet: the structure of the foot has been used to infer hindlimb locomotion; rostral shapes and proportions have been used to reconstruct dietary preference; and forelimb morphology has been used to predict flight style. Nearly all enantiornithines are dentulous, although reductions in the extent of dentition have evolved multiple times including the complete loss of teeth in the Late Cretaceous taxa *Yuornis juchangi* and *Gobipteryx minuta*. Until now, no edentulous taxon has been described from the Early Cretaceous. Here we introduce a new edentulous enantiornithine from the Jiufotang Formation, the youngest stage in the Jehol Biota. This new specimen indicates that the edentulism evolved earlier in enantiornithines than previously recognized. Re-examination of *Chiappeavis* suggests that edentulous rostra may have evolved multiple times among Jehol enantiornithines. Occlusion of the rostral skeletal elements together with the absence of teeth suggest this new taxon utilized a unique foraging strategy and diet different from previously described Early Cretaceous enantiornithines. Additionally, this new taxon exhibits unique appendicular morphologies which suggest powerful forelimb propulsion and comparatively strong pedal grip.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**CT SCANNING AND BRIEF DESCRIPTION OF CRETACEOUS ANURAN MATERIAL FROM PTEROSAUR HILL, TWO MEDICINE FORMATION, MONTANA**

Clark, Brendan A., Varricchio, David J.

Earth Sciences, Montana State University, Bozeman, Montana, United States

The anurans of the Two Medicine Formation have received very little treatment in the published literature relative to other vertebrate groups. A specimen referred to as the “little white bones” was recovered in 2019 at Pterosaur Hill, a locality about 150 m away from the Egg Mountain locality of the Two Medicine Formation. The tight aggregations of small bones required CT scanning to study further. After scanning, the data was segmented in 3DSlicer, and described in terms of the specimen’s anatomy and texture. This study tested the hypotheses that the “little white bones” either represented one or more regurgitalites egested by a predator, another type of gastric pellet that did not necessitate regurgitation, or calm, lacustrine deposition typical of the locality.

The “little white bones” consist of two fossiliferous pieces. Block 1 is approximately pyramidal in shape, and 7 cm by 5 cm by 5 cm in size. Block 2 is a flatter, triangular shape, and 5.5 cm by 4 cm by 3 cm in size. The matrix of both blocks is a gray, micritic mudrock typical of Pterosaur Hill’s lithology. Block 1 contains four, millimeter-scale elements with well-defined morphologies suggestive of an incomplete, lower pectoral girdle, a possible posteroventral portion of a braincase, and two other unidentified elements. Block 2’s elements are preserved in a more unique condition, forming a centimeter scale mass of six closely packed fragments aligned along their long axis. Many of these pieces are truncated by matrix-terminated breaks. Potential identifications of Block 2 include a mandible, a prootic, and a frontoparietal. Except for a teleost vertebral centrum located a few centimeters from the primary bone mass of Block 2, the elements in both pieces appear to belong to anurans similar to discoglossoids.

These are the first skeletal remains of anurans and teleosts at the Pterosaur Hill and indicate a richer, aquatic local fauna than previously thought. The matrix terminated breaks, parallel orientation, and clumping of elements in Block 2 suggest they represent a gastric pellet. Finally, this discovery is a promising start to CT scanning more Two Medicine specimens that often prove difficult for scanning and rendering.

**Funding Sources** Funding for CT scans was provided by the Undergraduate Scholars Program of Montana State University.

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Technical Session 6: Marine Reptiles (Wednesday, October 18, 2023, 1:45 PM)

**A REVISION OF THE GENUS *DOLICHORHYNCHOPS* WITH IMPLICATIONS FOR THE EVOLUTION AND BIOGEOGRAPHY OF POLYCOTYLIDAE**

Clark, Robert O., O'Keefe, F. R.

Biological Sciences, Marshall University, Huntington, West Virginia, United States

Polycotylid plesiosaurs were marine reptiles of the family Polycotylidae that diversified into multiple genera across the globe during the Late Cretaceous. Phylogenetic analyses have found disparate topologies within Polycotylidae, with low support values and polytomies hindering a confident assessment of the clade. The polycotylid genus *Dolichorhynchops* has repeatedly been found to be polyphyletic and in need of revision. Here we report a new polycotylid phylogeny featuring improved clade stability and branch support. We conducted a maximum parsimony analysis of 276 morphological characters in 120 plesiosaur taxa, with unordered character states and equally weighted characters. The exclusion of three wildcard taxa and addition of a newly discovered polycotylid improved clade resolution, eliminating all but one polytomy in Polycotylidae and raising Bremer decay indices in five polycotylid clades. We recovered the polycotylid clade Polycotylinae with no polytomies and most bootstrap percentages above 50%.

Informed by this new phylogeny, we reassess and redefine *Dolichorhynchops*, restoring its monophyly by removing taxa previously thought to be congeneric. We find *Dolichorhynchops* to consist of *D. osborni* holotype KUVP 1300, its referred specimens, and *D. herschelensis* holotype RSM P2310.1. The genus is within a clade of highly derived members of Polycotylinae confined to the Western Interior Seaway and present from its peak in the late Turonian to its closing in the Maastrichtian. The only other clade of polycotylids to survive as late as the Maastrichtian were the circumpolar occultonectians, which retained basal polycotylid characters. In contrast, advanced polycotylines of the clade that includes *Dolichorhynchops* were the culmination of several evolutionary trajectories evident throughout Polycotylidae: rostral narrowing and elongation, mandibular symphysis elongation, postorbital cranial foreshortening, parasphenoid flattening, and teeth becoming increasingly homodont. Despite these shared traits, the Pierre Shale polycotylines were disparate in other aspects of their morphology and in size, suggesting differential niche occupation in the Campanian waters of the Western Interior Basin.

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Technical Session 19: Theropods - II (Saturday, October 21, 2023, 1:45 PM)

**UPPER CRETACEOUS (MAASTRICHTIAN) THEROPOD SWIM TRACES IN BOLIVIA AND THEIR BEHAVIORAL AND PALEOENVIRONMENTAL SIGNIFICANCE**

Clawson, Roger E., McLarty, Jeremy A., Esperante, Raul

Earth and Bio. Sciences, Loma Linda University, Chilliwack, British Columbia, Canada

Abundant theropod swim traces occur in the Carreras Pampa track site at the Torotoro National Park, Bolivia. They are preserved as concave epireliefs on the surface of ooid, ostracod-rich quartz arenite that also has abundant tridactyl dinosaur tracks. The layer with traces and tracks is part of the middle member of the El Molino Formation (Upper Cretaceous, Maastrichtian). A total of 150 swim trackways were found across four areas within the Carreras Pampa site. The trackways vary in number of traces within each trackway, from as little as one to as many as 118, and 26 trackways have 10 or more swim traces. The trackways show alternating left and right traces consisting of a long primary medial scratch often accompanied by secondary smaller scratches on one or two sides. The medial scratches typically are 12-45 cm long, comma-shaped, tear drop shaped, or straight. Many of them have a posterior sediment displacement rim (expulsion rim). The traces show consistent, regular spacing of 0.7 to 1.2 meters. Most of the swim trackways studied follow a remarkable straight swim path with only slight deviations in direction. The longest swim trackway exposed in the site is TS-76, measuring 130.7 meters in length with a total of 118 exposed traces. There are 9 missing in the succession either because of erosion or no claw contact by the swimming animal. The first two thirds of this trackway show traces with the same orientation, which changes in approximately the last

one third with right traces parallel to baseline and the left traces oriented to an average of 30.1 degrees to baseline. This feature may suggest that the animal was attempting to compensate for a water current that was not present during the first two thirds of the trackway. Some of the swim traces cut through the true tridactyl tracks. The occurrence of swim traces overprinting tridactyl tracks indicates that water level rose after theropod dinosaurs had walked on soft substrate leaving footprints. The sediment of the substrate must have remained soft during both the formation of the tridactyl tracks and the swim traces and began lithification relatively rapid before water currents or bioturbation could erase them. Swim direction data for all 150 swim tracks, (1,115 individual traces), shows a dominant south- southeast direction of travel.

**Funding Sources** We thank the Geoscience Research Institute for funding this research, the Torotoro National Park for their help, and the local residents.

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

### CHONDRICHTHYANS AND OSTEICHTHYANS OF THE SKELLEY LIMESTONE (CONEMAUGH GROUP: CARBONIFEROUS, GZHELIAN) OF OHIO

Cline, Daniel A.[1], Shell, Ryan[2], Cheshire, Jamie[1], Ciampaglio, Chuck[1], Fuelling, Lauren[1]

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The Skelley Limestone (Casselman Formation, Conemaugh Group) of southeastern Ohio is a fossiliferous limestone formed in the late Carboniferous Period. Throughout the Appalachian Basin of the east-central United States, repeated changes in sea level deposited alternating terrestrial and marine sediments. The Skelley Limestone represents the last major marine transgression within the Conemaugh Group and within the Gzhelian Stage (303.7 – 298.9 million years ago) of the Appalachian Basin. From Noble and Muskingum Counties, three outcrops of the Skelley Limestone were identified and explored for vertebrate fossil remains. Bulk limestone samples (20+ kg) collected from each site were acid-washed, sieved, and the resulting material examined under stereomicroscope. 21 distinct taxa of chondrichthyans and other near-shore marine vertebrates have been identified from the sediment of the Skelley Limestone in this investigation. This diversity of marine vertebrate taxa indicates that there was a high species richness within the Appalachian Basin near the end of the Carboniferous Period. Ubiquitous taxa of the Late Carboniferous, such as *Cooleyella*, *Deltodus*, *Denaea*, *Heslerodus*, and *Petalodus*, have been previously reported from the Skelley Limestone and were found in abundance in this study. Remains of palaeonisciform, platysomid, and palaeoniscoid osteichthyans were also recovered and reported from the Skelley Limestone for the first time. Chondrichthyan taxa that appear for the first time in the Conemaugh Group from this study include *Glikmanius myachkovensis*, *Ossianodus*, and *Diablodontus*, which represent significant extensions to the paleogeographic and biostratigraphic ranges of these taxa.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

### A MODEL FOR ESTIMATING PRECISE DIETARY COMPOSITION OF FOSSIL ANTHROPOIDS

Cobb, Savannah E.[1], Locke, Ellis[2], La, Duong[3], Kirchhoff, Claire[4], Terhune, Claire[5], Cooke, Siobhan B.[1]

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Primate diets are diverse and complex, yet ecomorphological analyses of fossil primates often flatten this complexity into simplified categories such as ‘frugivore’ and ‘folivore’. As primate teeth must process food items of various material properties without breakage or excessive wear, it is important to consider multiple food sources when analyzing a species’ dental morphology. By linking primate dental morphology to multiple food sources within a species’ diet, we may more precisely infer dietary ecologies of fossil primates and improve our

understanding of the ecological factors that underlie major primate radiations.

The majority of studies linking dental morphology and diet have focused on molars, overlooking potential dietary signal in premolars, which play an important role in food processing. To rectify this gap in our understanding, this study focuses on mandibular 4th premolars (P4). We trained predictive models to infer maximum dietary percentages of fruit, leaves, seeds, and insects using linear and topographic measures of P4s from extant anthropoids (19 cercopithecoid species, 12 platyrrhine species, and 11 hominoid species; total n=184). Ecological data were taken from the literature; maximum reported annual percentages for fruit, leaves, seeds, and insects were chosen under the assumption that dental morphology reflects a species' potential niche, i.e., the upper limits of its diet. Models were trained using the caret package in R. Model performance as approximated by Root Mean Squared Error (RMSE) was good when inferring percentages of insects (RMSE=6) and seeds (RMSE=11) and moderate when inferring percentages of leaves (RMSE=18) and fruits (RMSE=17) in the diets of extant sample taxa. We used these models to reconstruct diet of three early Miocene fossil catarrhines from Kenya: the stem hominoids *Ekembo nyanzae* (n=1) and *Proconsul major* (n=2) and the stem cercopithecoid *Noropithecus bulukensis* (n=1). Though these taxa have previously been classified as frugivores based on molar morphology, all taxa were classified as mixed feeders with high proportion of frugivory (≤40% to ≤47%) and folivory (≤37% to ≤44%). *Proconsul* was predicted to have had a substantial component of seed-eating (≤14%). Our results suggest that early Miocene catarrhines may have relied more on folivory and exhibited greater dietary diversity than previously thought. Furthermore, these findings highlight the utility of including premolars in ecomorphological analyses.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

## ONTOGENY-INDUCED SHAPE CHANGES IN THE PROXIMAL FEMUR OF THE AMERICAN ALLIGATOR (*ALLIGATOR MISSISSIPPIENSIS*)

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The tetrapod skeleton uses appendicular joints to articulate between limb elements. Appendicular joints are composed of articular cartilage and other joint soft tissues that facilitate various mechanical and physiological functions. However, while the growth and development of mammalian and avian appendicular joints have been extensively studied, this system has thus far been poorly documented in crocodilians. This study investigates the ontogenetic development of the proximal end of the American alligator's femur. We hypothesize that as alligators grow, the bony surfaces of their joints undergo ontogenetic shape change. The hind limbs from a growth series of alligators were dissected and prepared for photography, as well as 3D capture using photogrammetric and computed tomographic techniques. The femoral proximal ends were captured without cartilage caps and underwent 2D geometric morphometric analysis to quantify shape change during growth. Our results show that both the growth plate and the metaphyseal line of the alligator's proximal femora become progressively convex as the alligator ages. However, ontogenetic shape changes could only be detected in the capital and lateral sides of the proximal femur, whereas the medial side only reveals a pattern of shape change in the femoral growth plate, and no patterns of shape change could be detected from the trochanteric side. This suggests that the bony surface of an American alligator's proximal femoral head becomes more congruent with its cartilage cap as the alligator matures, similar to the condition observed in birds and mammals. This study provides a basis for inferring the morphology of archosaurian joint cartilage using bony surfaces but also emphasizes a limitation to using 2D geometric morphometric techniques in quantifying three-dimensionally complex specimens such as vertebrate limb joints.

**Funding Sources** This research is supported by the Graduate Studies Graduate Assistantships of Southern Connecticut State University.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

## THE JUVENILE CRANIUM AND UPPER DECIDUOUS DENTITION OF *MEGALADAPIS*

***MADAGASCARIENSIS* (LEMUROIDEA, STRESIRRHINE, PRIMATES)**

Collins, Regan I.[1], Borths, Matthew R.[2], Borrelli, Chiara[1]

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The living diversity of lemurs includes over 100 species spread across the diverse ecoregions of Madagascar. The late Pleistocene and Holocene subfossil record from Madagascar expands this diversity to include 17 extinct species, all larger than any extant lemur species. Numerous studies have explored this diversity by focusing on variation in life-history strategies in lemurs and other strepsirrhines, comparing them to haplorhine primates. In general, strepsirrhines gestate, wean, and reach sexual maturity more rapidly than haplorhines, but differences in relative brain size, body size, and ecology complicate these comparisons. *Megaladapis madagascariensis* is an extinct, large bodied (~46 kg) folivorous lemur that can provide an important point of reference in these studies, but early phases of *M. madagascariensis* ontogeny are necessary to develop these comparisons. Here, we describe a complete juvenile cranium of *M. madagascariensis* from Anjohibe cave in northern Madagascar. The specimen preserves the complete deciduous premolar row. MicroCT scans reveal the developing paracones of the canine, P2, and P3 are present in the crypts between the roots of the deciduous dentition. The crypt of M1 is preserved, though the crown is absent and the M1 alveoli are not fully developed. Using growth rate data collected from *M. edwardsi* dentition, the state of dental development in this specimen of *M. madagascariensis* suggests that it was less than one year-old at time of death. The entire cranium is about 55% the total length of an adult cranium from Anjohibe cave. As expected in such an immature individual, the rostrum is relatively short, post-orbital constriction is limited, and the nuchal crest is relatively small compared to the adult. This specimen also preserves an intact braincase, facilitating comparisons between the juvenile and adult endocasts from *Megaladapis* and extant lemurs at comparable developmental stages. Overall, the juvenile cranium supports previous observations that – adjusted for its large body mass – *Megaladapis* life-history was consistent with the relatively accelerated life-history of other strepsirrhines. These observations provide important context and model parameters for exploring the impact of the very recent extinction of *Megaladapis* and other large-bodied lemurs in Madagascar.

**Funding Sources** NSF DBI 2023087; IMLS MA-245704-OMS-20

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**NEW MAMMALS FROM THE LATE CRETACEOUS FROM ALLEN FORMATION (PATAGONIA, ARGENTINA) AND THE RISE OF MERIDIOLESTID DENTAL DIVERSITY**

Connelly, Brigid E.[1], Cardozo, Mauricio S.[2], Montgomery, Joshua D.[3], Rougier, Guillermo W.[1]

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The record of Late Cretaceous mammals from South America rests heavily on the collections from three northern Patagonian Formations: Los Alamitos, Allen, and La Colonia. All three are regarded as Maastrichtian, with La Colonia spanning the K/P boundary. The mammals from Allen Formation are represented by a handful of specimens including dryolestoids and a ferugliotheriid. We report here on a new collection of specimens from the Cerro Tortuga locality, focusing on the dryolestoid material that represents a new taxon. We also refer material to dryolestoid taxa already described from Allen or Los Alamitos Formations.

We identify a new genus and species of dryolestoid based on 3 isolated lower molariforms. Several characters – particularly cusp arrangement, root shape, presence of cingulids, and the complex trigonid basin shape – make it easy to recognize as a new taxon. The new mammal shows a combination of characters shared with both the plesiomorphic sharp-toothed Cronopioidea and the more herbivorous and bunodont mesungulatomorphs. We suggest that presence of a well-developed cingulum, partial mesiodistal root compression, and mesial shift of metaconid are precocial acquisitions in the lineage leading to Mesungulatidae. Larger size, thicker enamel, and bunodont cusps diagnose more deeply nested mesungulatids.

Additionally, we refer 18 isolated specimens to previously described dryolestoid taxa. A maxillary fragment with two molars, plus isolated molariforms and one edentulous dentary fragment, are referred to *Groebertherium*. This taxon has been consistently recovered as a member of the northern radiations of dryolestoids, the Dryolestidae. However, a new reconstruction of *Groebertherium* using all available material shows a low number of molars and a dental arcade similar to that of other meridiolestids, suggesting that its similarities to northern Dryolestidae are convergent.

Other remains in this collection allow for more complete reconstructions of the dentitions of several species and challenge some previous dental identifications and hypotheses of cusp homology. We hypothesize that the new taxon represents a dietary shift within dryolestoids from insectivory to herbivory, highlighting a sequence of character transformation. The new taxon and character polarity supports earlier hypotheses regarding mesungulatids as deriving from more generalized and insectivorous meridiolestids.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**DISTRIBUTION, FREQUENCY, AND HISTOLOGY OF PATHOLOGICAL ELEMENTS IN CENTROSAURINAE**

Conway, Brian[1], Peterson, Joseph E.[2]

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Pathologies, or indications of trauma and disease, on fossil specimens provide clues to the lifestyles and behaviors of extinct organisms. Skeletal pathologies may indicate habitual behaviors or environmental pressures if present within multiple individuals of a species, especially within population samples. Monospecific bonebeds in Alberta provide unique opportunities to examine large samples of nonavian dinosaurs, providing insight into their population biology. Direct evidence for intraspecific combat in ceratopsian dinosaurs has previously been systematically examined, and cranial pathologies in *Triceratops* and *Centrosaurus* are well documented, namely pitting, lesions, and fracture calluses. These pathologies were interpreted as healed wounds from direct combat between conspecifics. Other anomalous pits and fenestrae on the skull have been interpreted as signs of infectious disease or senescence. Many of these studies focus primarily on the skull, leaving the postcranial skeleton underexplored.

Previous work shows that inflated lesions and resorption pitting occur on the rib cage and pelvic girdle of *Triceratops* and *Pachyrhinosaurus*. Ceratopsid specimens commonly show healed rib fractures, in addition to ankylosed vertebrae, pseudarthrosis, and other pathologies. Collections from monodominant death assemblages of *Centrosaurus apertus* and *Pachyrhinosaurus lakustai* at the Royal Tyrrell Museum of Paleontology were surveyed for new pathological specimens. This would better reflect true incidences of pathology within each bonebed and perhaps their whole populations. Specimens from each *C. apertus* bonebed were pooled for comparison with *P. lakustai*. Several pathological specimens were selected for histological sectioning to study their tissue microstructures and responses to trauma and attrition. Several new specimens from bonebeds 30, 91, 41A, and the Pipestone Creek bonebed were recognized as pathological, adding to the database of unusual elements for *Centrosaurus apertus* and *Pachyrhinosaurus lakustai*. Histological thin sections from a posterior dorsal rib with a fracture callus, an anterior dorsal rib with an infected pseudarthrosis, and a posterior caudal vertebra with anomalous pitting were taken. Relatively low frequencies and similar distributions of postcranial pathology suggest similar intraspecific behaviors or environmental pressures in both species.

**Funding Sources** University of Wisconsin-Oshkosh Graduate Student-Faculty Collaborative Grant Dinosaur Research Institute Student Project Reimbursement

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**THE OSTEOHISTOLOGY OF *BAPTORNIS***

Cooper, Christian, Fabbri, Matteo, O'Connor, Jingmai

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The Hesperornithiformes are a diverse clade of flightless Cretaceous birds found in North America and Eurasia. They have been interpreted as aquatic

based on specialized features of the hindlimb including a well-developed cnemial crest and modified fourth pedal digit as well as based on the marine deposits in which their fossils are found. Aquatic habits are further supported by morphometric similarities with extant foot-propelled swimmers. Although eleven genera have been named, only *Hesperornis* has been previously sectioned for osteohistology. Here we provide the first detailed description of the osteohistology of the genus *Baptornis* with the hopes of drawing comparisons between it and *Hesperornis* to explore potential ecological and developmental diversity within this clade. The specimen *Baptornis* FMNH UC395 is an immature individual, which may affect its histological structure. The cranial and caudal sides of the cross-section of the sample's femur are distinct. The cranial side consists of an inner layer just outside of the medullary cavity that is devoid of osteons and dominated by sparse radial vascularity. The area from the outer edge of this layer to the periosteal boundary consists of Haversian bone with oblong primary osteons that become more tightly concentrated as they approach the periosteum. The caudal side of the cortex consists of fibrolamellar bone with laminar and reticular vascularization. We also find evidence of osteosclerosis, or the invasion of medullary cavity by bone tissue. This adaptation is strongly correlated with aquatic lifestyles in extant vertebrates and widely understood to assist them in counterbalancing buoyancy during dives. These findings, in tandem with the lack of observed osteosclerosis in *Hesperornis*, paint a more complex picture of the evolution and diversity of aquatic lifestyles among Hesperornithiformes.

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Technical Session 16: Theropods - I (Saturday, October 21, 2023, 8:00 AM)

**DIVERSITY AND DISTRIBUTION OF *DASPLETOSAURUS* MAXILLARY MORPHOTYPES EXCEEDS KNOWN SPECIES DIVERSITY**

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Biological Sciences, University of Alberta, Edmonton, Alberta, Canada

Over the past decade our understanding of diversity within the genus *Daspletosaurus*, originally described from the Oldman Formation (OMFm) of Dinosaur Provincial Park (DPP), Alberta, has been greatly expanded with the description of *D. horneri and D. wilsoni* from the Campanian of Montana. Evidence for an additional two species from Alberta, one from the OMFm of the Milk River region (MR), and the other from the Dinosaur Park Formation (DPFm), has been previously reported, but this material has yet to be diagnosed. Maxillary morphology has been successfully utilized in prior studies to visualize variation and identify distinct morphotypes. In this study maxillae associated with three named *Daspletosaurus* species, the MR *Daspletosaurus*, and the DPFm *Daspletosaurus* were compared to identify consistent morphologies and describe distinct morphotypes supported by congruent cranial characters. Morphotype assignment was initially performed using discrete characterization. Linear measurement and landmark geometric morphometrics were then used to quantitatively test discrete characterizations and look for taxic and spatiotemporal trends in maxillary morphologies. Discrete characterization of the maxillae demonstrate morphotypes for both the MR *Daspletosaurus* and the DPFm *Daspletosuarus* distinct from the currently accepted *Daspletosaurus* species. Morphometric analyses uncovered aberrant forms over a spatiotemporal distribution of what is now western North America, supportive of initial morphotype assignment. A shallow maxillary morphology appears plesiomorphic in the DPP, Alberta region taxa (*D. torosus* and the DPFm *Daspletosaurus*), while the taxa south of this region (*D. horneri, and the MR Daspletosaurus*) consistently demonstrate deeper maxillary morphologies. Additionally, a narrow pila promaxillaris defines the northern morphs whereas this feature appears broad in southern forms (except the *D. horneri* holotype). Despite *D. wilsoni* possessing a broad pila promaxillaris, its maxilla was found to be most similar in morphology to *D. torosus*. This similarity is most likely due to a close shared ancestry regardless of observed spatiotemporal trends. The presence of five distinct maxillary morphotypes exceeds currently described species diversity and occurs over a relatively brief geological period (2 My). These findings suggest that *Daspletosaurus* was very diverse, undergoing rapid lineage splitting challenging previous claims to anagenetic speciation within the clade.

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Technical Session 11: Archosaurs (Friday, October 20, 2023, 8:00 AM)

**EXTANT CROCODILIAN BONE PATHOLOGIES AS A WINDOW TO PHYTOSAUR PALEOPATHOLOGY**

Cornille, Alexis D.[1], Witzmann, Florian[1], Asbach, Patrick[2], Wolff, Ewan[3], Clarac, François[4]

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Paleopathology is a powerful tool to reconstruct aspects of the physiology and paleoecology of long-extinct animals. However, diagnosing ancient diseases is often not straightforward. Most studies on bone physiology in extant vertebrates have been only performed in humans or in domesticated animals. Nonetheless, physiological and ecological differences should be considered between phylogenetically remote groups.

The middle to late Triassic phytosaurs have an abundant and well-sampled fossil record making them well suited for a large-scale paleopathological study. Their striking ecomorphological similarities with extant crocodilians and their phylogenetic position as the sister group of archosaurs or as basal pseudosuchians, make extant crocodilians an ideal analogue model. Here we present the first results of an epidemiological survey of skeletal pathologies in extant crocodilians.

This survey is based on firsthand studies of 845 crocodilian specimens composed of 683 skulls, 92 isolated crania, 8 isolated mandible rami, and 65 skull fragments. The post-cranial skeleton is represented by at least one isolated bone in 127 specimens. A minimum of one bone pathology has been found in 349 specimens from which 57% belong to the skull. Preliminary diagnoses show a dominance of trauma in 42% of cases from which 16% are bone fractures. Infectious diseases make up to 21% of cases, joint disorders 15%, dental diseases 6%, congenital malformations and metabolic diseases represent 5% each, possible neoplastic diseases 3%, and the rest are ankylosed vertebrae. The main pathologies of the cranium and mandibles are traumatic injuries, representing 50% and 43% of cases respectively, and interpreted as a consequence of intraspecific fighting and feeding behavior. The appendicular skeleton shows 33% of trauma (64% being bone fractures), and 30% of infectious diseases. Joint disorders and infectious diseases each affect the spine in 29% of cases. Rib traumata represent 42% of observed pathologies, of which 91% are fractures. The girdle structures show 43% of joint disorders and 39% of infectious diseases. Finally, 94% of osteoderm pathologies are traumatic injuries.

This review will provide important comparative data for our ongoing paleopathological studies of phytosaurs which has yielded 270 pathological bones. Moreover, our data on crocodilian osseous pathologies will certainly be useful for future paleopathological studies of archosaurian clades including dinosaurs.

**Funding Sources** This research is funded by the DFG-grant WI 3144/5-1

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Virtual Posters

### *CHRYSOCHAMPSA MYLNARSKII* FROM THE EARLY EOCENE GOLDEN VALLEY FORMATION OF NORTH DAKOTA, U.S.A. REVEALS A LATE-LIVED MEMBER OF A CRETACEOUS CLADE

Cossette, Adam P.

Biomedical and Anatomical Sciences, NYITCOM-AR, Jonesboro, Arkansas, United States

Since its discovery the phylogenetic affinities of *Chrysochampsa mylnarskii* have been controversial and a number of placements have been proposed. Recent advances in the knowledge of crocodylian morphology and systematics renders this species an ideal candidate for reevaluation and redescription. *Chrysochampsa mylnarskii* was established upon YPM-PU.17258, a mostly complete skull, atlas intercentrum, and osteoderms originally stored in the collections of Princeton University (PU) and now housed at the Yale Peabody Museum (YPM). The specimen, from the early Eocene Golden Valley Formation of Stark County, North Dakota, preserves a 40 cm skull that was compressed during burial - alteration of the specimen conceals sutures in many of the affected areas. The species is large compared to other Eocene alligatoroids, and especially so among its North American relatives. Its relatively unspecialized dental arcade - similar to modern *Alligator mississippiensis* – combined with a gently tapering, blunt snout indicate a generalized predator. The most recent study of the taxon determined it to be a junior subjective synonym of *Allognathosuchus*. However, the authors did not use a phylogenetic analysis to determine the relationships and relied on general similarities to make their systematic conclusion. Here, a phylogenetic study including new character states coded directly from the holotype and yet to be published specimens referable to the species, places the enigmatic taxon in an unanticipated clade. Reanalysis of the holotype specimen shows that the species is diagnosed by an autapomorphy - an extremely wide posterior frontal bone such that the postorbitals do not form a part of the orbital margin – and description of the previously unpublished specimens place the species in an ontogenetic sequence. Exploration of *Chrysochampsa mylnarskii* reveals both derived and plesiomorphic features in an early, phylogenetically basal globidontan alligatoroid and extends the range of a clade previously known from the Cretaceous deep into the Cenozoic.

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**FLYING HIGH: A NEW SPECIES OF *DIOMEDEA* (AVES, DIOMEDEIDAE) AND IMPLICATIONS FOR THE PALEOECOLOGY OF THE PACIFIC NORTHWEST MIOCENE**

Coultley, Alyssa N., Davis, Edward B., Ward, Pat

Earth Sciences, University of Oregon, Eugene, Oregon, United States

The Astoria Formation, OR, USA produces spectacular marine invertebrate and vertebrate fossils from the middle Miocene, including hundreds of published fish and marine mammal specimens. Despite this wealth of fossils, only one avian specimen has been described. A new specimen suggests the presence of a new albatross species (Diomedeidae) based on morphological comparisons to extinct and extant albatrosses. This specimen has an elongated beak, which is used as a diagnostic criterion for avian species. Compared to other documented extinct albatrosses (including “The Astoria Albatross”), the new species described here is more robust, yet is smaller than extant species. This size differential is substantial enough to declare a new species. Likewise, the potential for habitat overlap between this novel species with other extinct diomedeids is minimal, giving credence to the assignment of this new species. Overall, the identification of a new avian species creates a better understanding of the unique geologic, geographic, and paleoecological nature of the Astoria Formation during the Miocene.

**Funding Sources** University of Oregon Museum of Natural and Cultural History

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Technical Session 3: Fishes & Amphibians (Wednesday, October 18, 2023, 8:00 AM)

**MORPHOLOGICAL ANALYSIS OF A NECTRIDEAN LEPOSPONDYL, *DICERATOSAURUS*, FROM LINTON AND FIVE POINTS, OHIO.**

Creighton, Jamey[1], Anderson, Jason[2]

[1]Biological Sciences, University of Calgary, Calgary, Alberta, Canada, [2]Veterinary Medicine, University of Calgary, Calgary, Alberta, Canada

Lepospondyli is a group of small-bodied tetrapods that traditionally includes five Paleozoic Orders: Microsauria, Lysorophia, Nectridea, Aistopoda, and Adelosondyli, which are united by the presence of elongate trunks and holospondylous vertebrae. However, more recent studies have shown some of these taxa are likely a polyphyletic assemblage. Nectridea, which is thought to be quite basal in the early tetrapod phylogeny, has not yet been included in these studies; more information needs to be collected to test the interrelationships of nectrideans among early tetrapod groups. This study focuses on *Diceratosaurus*, a nectridean solely known from Linton and Five Points, Ohio. Silicone peels of the skull roof and the palate were analyzed and illustrated by using photography and light microscopy. Results suggest that this dataset comprises of two distinct morphs that altogether range from 14-25cm in skull length: a broad, round-snouted morph (known as *D. brevirostris*), and a small, narrow-snouted morph which has never been seen in nectrideans before. We test several hypotheses to explain this variation including ontogenetic change, polymorphism, and the presence of multiple species or genera. Examining the smallest specimens, which are the narrow-snouted morphs, to the largest specimens, which are the broad-snouted morphs, there seems to be no signs of an ontogenetic difference; the dermal ornamentation is organized with distinct pits and ridges, all bones in the skull roof are ossified, and the sutures are tightly closed in the smaller narrow-snouted morphs. This is not what one would expect if the narrow morph were a juvenile form of *Diceratosaurus.* There is also no significant difference between the morph's mean relative horn to skull length, a growth linked trait. There are, however, differences in the bones of the anterior region of the skull roof and in the palate, which lead us to believe these are two separate genera. We also include the information gained from this study into a phylogenetic analysis to test *Diceratosaurus* and the narrow morph's relationship to one another and to other nectrideans. We hypothesize that the narrow morph is more closely related to more derived nectrideans like *Diplocaulus* than to *Diceratosaurus*. The discovery of a second morph and these results could further support the conclusion that not only nectrideans, but lepospondyls as a group, are more diverse than originally thought.

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Technical Session 17: Afrotheria & Mammal Macroevolution (Saturday, October 21, 2023, 8:00 AM)

**NEW PALEONTOLOGICAL AND GEOLOGICAL DATA FROM THE MIDDLE MIOCENE OF NAZARENO, SOUTHERN BOLIVIA**

Croft, Darin A.[1], Adojoh, Onema[2], Anaya, Federico[3], Engelman, Russell[4], Galarza, Michaela[2], Levin, Naomi E.[5], Saylor, Beverly Z.[2]

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Global climate, floras, and faunas underwent substantial changes during the early to middle Miocene. The Central Andes preserve a rich fossil record of terrestrial paleoenvironments from this interval, making it one of the few Neotropical areas amenable to studying biotic responses to these changes. Here, we report new data from Nazareno, an expansive basin in southern Bolivia (~30 km of exposures). The few previous studies of this basin have focused on two areas in the south near the town of Arenales. A new area discovered by our team in 2022 ca. 15 km to the north has yielded a partial tortoise carapace (*Chelonoidis* sp.) and microvertebrates including rodents (*Acarechimys* sp.) and marsupials (Palaeothentidae; Abderitidae: cf. *Pitheculites*). Pedogenic development in this area is greater than in southern sites and suggests high seasonality; it includes minor streaks and nodules of carbonate plus common green and red mottles within horizons of reddish mudstone. Twenty-one species of mammals of 17 families have been identified from the Nazareno Basin. Several species are shared with Cerdas and suggest an early middle Miocene (Langhian) age. A specimen of *Thoatherium* extends the geographic range of this litoptern nearly 3,000 km to the north and likely extends its temporal range by ≥ 2 million years. Stratigraphic studies of the southern basin support recognition of three primary units above a basal conglomerate. Conglomerate beds are mainly clast-supported, up to ~5 m thick, and pass eastward into sandy mudstone. The lower unit above the conglomerate is mainly composed of reddish mudstones with intervals of biotite-rich sandier interbeds. The middle unit includes three laterally traceable resistant units of conglomeratic sandstone separated by thinner, less resistant beds of sandstone and mudstone. The upper unit, difficult to access, includes a prominent volcanic ash and laterally persistent lighter and darker bands of reddish mudstone. The sandstones are massive, sheetlike or fill wide channels, and represent confined and unconfined flow. The mudstones include thinly interbedded siltstone and claystone with distorted bedding and desiccation cracks plus reddish mudstone with clay- and sand-filled burrows, root casts, and mottles. They represent overbank and more proximal floodplain settings. No pedogenic carbonate was found, and 12 samples analyzed for pollen and phytoliths were barren. Vertebrate fossils occur throughout the section, mainly in mudstones.

**Funding Sources** Expanding Horizons Initiative, Case Western Reserve University College of Arts and Sciences

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**AN ANKYLOSAUR FEMUR FROM THE DUNVEGAN FORMATION OF NORTHEASTERN BRITISH COLUMBIA**

Cross, Emily G.[1], Arbour, Victoria[2]

[1]University of Victoria, Victoria, British Columbia, Canada, [2]Royal BC Museum, Victoria, British Columbia, Canada

Little skeletal dinosaur material is known from the mid-Cretaceous of Canada, however, the

Cenomanian-aged Dunvegan Formation of northeastern British Columbia and northwestern Alberta is rich with ichnofossils attributed to nodosaurid ankylosaurs. A long bone collected in 1993 from the Murray River of northeastern British Columbia is identified here as a left ankylosaur femur. Femoral measurements of the bone plotted against femoral measurements of major dinosaur clades, combined with observations on femoral features, indicate the bone belongs to ankylosauria. This specimen represents the first limb bone material recovered from the Dunvegan Formation. Previous skeletal ankylosaur material described from the Dunvegan Formation includes associated vertebrae and ribs from British Columbia and osteoderms from Alberta. The specimen is too damaged to assign to Nodosauridae or Ankylosauridae. The Cenomanian is a time of great ecological change in North America, including the possible extirpation of ankylosaurid ankylosaurs. Fossils from the Dunvegan Formation can thus yield important insight into the responses of fauna to these major transitions.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**PRELIMINARY TAPHONOMY OF A REVUELTIAN (UPPER TRIASSIC: NORIAN) AGE COPROLITE ASSEMBLAGE FROM THE HOMESTEAD SITE IN THE GARITA CREEK FORMATION, EAST-CENTRAL NEW MEXICO, USA.**

Crouch, Joshua N.[1], Carter, Caedan[1], Heckert, Andrew B.[1], Lauer, Bruce[2], Lauer, Rene[2]

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Studies of vertebrate paleoecology and diversity rely on diverse modes of fossil occurrence. Within the wider paleontological community, paleoscatology remains understudied, despite the significance coprolites reveal about a region or locality's ecology and predator-prey interactions. Homestead is a microvertebrate site within the Garita Creek Formation of east-central New Mexico and is of Triassic, specifically Revueltian (Norian) age. Among the tens of thousands of identifiable bones, scales, and teeth from Homestead is a rich collection of thousands of coprolites. Just as with the bone themselves, these coprolites are paleoecologically important, as many include diagnostic microvertebrate fossils and thus not only contribute to our understanding of Triassic paleodiversity but are direct evidence of predator-prey interactions. We have examined a subset (n=2002) of Homestead coprolites, finding that 342 (17%) preserve visible fish scales in either external (~70%) or cross-sectional (~30%) views. We have divided the Homestead coprolites into three broad categories, nondiagnostic pellets (~86%), striated (12%), and spiral (~2%). Two of these categories are ichnotaxonomically diagnostic (those with striations or spirals), and therefore possibly indicative of perpetrator. Of the scale-bearing coprolites, ~7% bear striations, 3% spirals, and the rest are nondiagnostic. Although nondiagnostic coprolites are more likely to have visible scales on their exterior (~73%), the diagnostic coprolites are more likely to have visible scales in cross section (~69% of striated, ~44% of spiral) than on external surfaces, suggesting that scanning (e.g., micro-CT) complete, striated coprolites can yield significant fossils and warrant the examination of coprolites from other Triassic sites.

Coprolites have their own ichnotaxonomy. The striated coprolites most closely resemble the ichnotaxon *Alococopros triassicus* (potential archosauromorph perpetrator) due to lateral striations that lead to furrowed, rounded edges. The spiral coprolites may pertain to *Heteropolacopros* (potential spiral valved perpetrator--coelacanths, sharks, and possibly lungfish). The specimens we tentatively identify as *Alacocopros* includes an apparently novel morphology, where the lateral striations emerge from beneath a layer of fecal matter. Our results suggest that other Chinle coprolites should be investigated for inclusions and reevaluated for their paleoecological significance.

**Funding Sources** We thank the Lauer Foundation for Paleontology, Science, and Education for providing us with the fossils studied.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**NEW INSIGHTS INTO THE CRANIAL ANATOMY OF THE PALEOCENE PLESIADAPIFORM *PLESIOLESTES NACIMIENTI* (EUARCHONTA, PALAECHTHONIDAE)**

Crowell, Jordan W.[1], Beard, K. Christopher[2], Chester, Stephen G.[3]

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A half century ago, a partial cranium of the palaechthonid plesiadapiform *Plesiolestes nacimienti* (KUVP 9557) from the early Paleocene (To2 interval zone of the Torrejonian North American Land Mammal 'age') of the San Juan Basin, New Mexico, was described and evaluated to infer the ecology of the ancestral primate. Additional crania representing several plesiadapiform families have since been described, yet this specimen remains the best-preserved cranium of a palaechthonid and is the oldest known cranial fossil of a plesiadapiform. We µCT scanned the cranium of *P. nacimienti* for the first time, which allowed us to study previously undocumented internal anatomy, assess previously described cranial morphology, and make new comparisons with crania of other plesiadapiforms and euarchontan mammals (primates, colugos, treeshrews). While several of the original cranial descriptions were correct, such as the posterior expansion of the nasal bone and the relative size of the infraorbital foramen, new observations from µCT data have helped resolve other previous morphological interpretations, such as the olfactory bulbs being in a more posterior position (dorsal to the upper third molars) than previously hypothesized and the absence, rather than the presence, of a postorbital process. The posterior position of the olfactory bulbs is like that of microsyopid and plesiadapid plesiadapiforms but differs from the more anterior position of the olfactory bulbs of paromomyid plesiadapiforms and extant euarchontans. The presence of a postorbital process was proposed based on anteriorly prominent temporal lines and an accentuated and laterally protrusive supraorbital margin. However, it should be noted that several other plesiadapiforms that lack postorbital processes have anteriorly prominent temporal lines. Also, µCT data reveal that previous identifications of an accentuated and laterally protrusive supraorbital margin are likely artifacts of extreme dorsoventral compression and fragmentation of the specimen. Therefore, *P. nacimienti* lacked a postorbital process, similar to the condition of non-microsyopid plesiadapiforms and unlike that of some microsyopids and other euarchontans. Overall, the cranial anatomy of *P. nacimienti* appears to be very plesiomorphic like that of other plesiadapiforms and lacks clear cranial synapomorphies with crown primates, colugos, or treeshrews.

**Funding Sources** This study was supported by the U.S. National Science Foundation (SBE 2216582**),** a Leakey Foundation Research Grant, and a PSC CUNY Award, City University of New York.

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**WELL-PRESERVED CROWN BIRD SYNSACRUM FROM THE LATEST CRETACEOUS HELL CREEK FORMATION OF SOUTH DAKOTA, U.S.A.**

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Here, we describe an ornithurine synsacrum represented by an isolated, but well-preserved complete element. The specimen, DMNH EPV.141543, represents the first documented synsacrum from the deltaic deposits of the Lower Cretaceous (Maastrichtian) Hell Creek Formation in South Dakota, U.S.A. DMNH EPV.141543 possesses several derived synsacral traits found among crownward avialans, suggesting a close taxonomic relationship with this particular group. To assess the taxonomic classification of DMNH EPV.141543, we conducted a comparative study with other ornithurine fossils and extant crown group avians. A cladistic analysis was also performed, including over 120 avian genera, both extinct and extant, ranging from basal enantiornithines to more derived neornithines. Based on the cladistic analysis, DMNH EPV.141543 is recovered as Ornithurine. Two trees were constructed, with the first tree resolving DMNH EPV.141543 as a basal hesperornithiform, more derived than *Enaliornis*. The second tree resolved DMNH EPV.141543 as more derived than Hesperornithiformes, but less derived than *Ichthyornis*. However, given the lack of other postcranial and cranial material of the specimen, we cannot rule out neornithine affinities. This discovery contributes to our understanding of the avifaunal diversity in North America near the Cretaceous-Paleogene boundary and provides a new context for the evolutionary history of crownward avialans.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

## MORPHOLOGICAL DISPARITY IN THE CAUDAL VERTEBRAL SEQUENCE OF *RAPETOSAURUS KRAUSEI* (SAUROPODA: TITANOSAURIA), FROM THE UPPER CRETACEOUS MAEVARANO FORMATION OF MADAGASCAR

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Two distinctive caudal vertebral morphs led to the hypothesis that at least two titanosaur taxa are represented in the Upper Cretaceous Maevarano Formation: *Rapetosaurus* and "Malagasy Taxon B" (MTB). The *Rapetosaurus* morph exhibits cylindrical centra with a 1:1 width/height ratio and relatively elongate neural spines. The second morph, provisionally designated as MTB, exhibits dorsoventrally compressed centra with width/height ratios between 2:1 and 3:1, more variable articular anatomy, and robust, low neural arches. The presence of a second titanosaur was subsequently confirmed by the discovery of an isolated autapomorphic braincase (*Vahiny*). We reviewed all sauropod vertebral remains from the Maevarano Formation, focusing on 239 caudals, with an aim to resolve whether the two caudal morphs represent different taxa. Our sample included three articulated/closely associated partial caudal series from different, but overlapping, regions of the tail, which made it possible to determine the relative positions of isolated specimens, including 44 proximal, 67 middle, and 88 distal caudals. The sample is ontogenetically broad and includes tiny embryonic/neonatal centra (0.7 cm) and caudal vertebrae associated with the largest known *Rapetosaurus* (femur length = 143 cm). These new data reveal that both caudal morphs can likely be attributed to *Rapetosaurus*. The disparate morphs represent an anatomical continuum drawn from different regions of a tail that exhibits high morphological disparity, particularly in the mid-to-distal caudal transition, and at the tip of the tail. Anterior and most mid-caudals retain typical *Rapetosaurus* morphology. Centra transitioning from more distal mid-caudals to distal caudals become increasingly elongate, dorsoventrally compressed, and bear robust, low-relief neural spines devoid of fossae and laminae. Distal caudals also exhibit highly variable articulations, including procoelous, opisthocoelous, biconcave, biconvex, and amphiplatyan. The most distal caudal centra are elongate and strongly biconvex. These features support the hypothesis that *Rapetosaurus* is a derived, lithostrotian saltasaurine, with phylogenetic affinities with *Lirainosaurus, Neuquensaurus,* and *Saltasaurus. Vahiny* fossils remain very rare, with only three caudal centra with morphologies inconsistent with the revised *Rapetosaurus* caudal baüplan. Lastly, strongly biconvex distal caudals indicate that *Rapetosaurus* possessed a highly flexible tail tip.

**Funding Sources** Funding was provided by the National Science Foundation (EAR-1528273; EAR-0955716), the National Geographic Society, the David B. Jones Foundation, & Macalester College.

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Virtual Posters

## DESCRIPTION OF NEW BRACHIOSAURID MATERIAL FROM THE LATE JURASSIC MORRISON FORMATION DRY MESA DINOSAUR QUARRY, REDESCRIPTION OF POTTER CREEK BRACHIOSAURID REMAINS, AND REFERRAL OF NEW LOCALITIES TO *BRACHIOSAURUS*

Curtice, Brian[1], Wilhite, Ray[2]

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Despite intense collecting for over 120 years in the Morrison Formation of western North America, the genotype of *Brachiosaurus*, *B. altithorax*, described by Riggs in 1903/4 from a single skeleton excavated in Colorado, remains the most complete specimen of this iconic, yet surprisingly poorly known, genus. The material consists of seven presacral, five fused sacral, and two caudal vertebrae; and a humerus, coracoid, femur, ribs, and ilia. No additional elements have been recovered from the locality.

Individual appendicular elements have been referred to *Brachiosaurus* in a number of publications over the last fifty years. However, the majority of these bones are not directly comparable to the holotype material. They were referred to *Brachiosaurus* on the basis of their size, gracility, and similarity to the related Tendaguru taxon, *Giraffatitan* (formerly *B. brancai)*.

Over 99.9% of the collected Dry Mesa Dinosaur Quarry field jackets have been prepared for study, producing thousands of bones and allowing for a thorough taxonomic assessment of the Quarry's six or more recognized sauropod genera: *Apatosaurus*, *Brachiosaurus*, *Camarasaurus*, *Diplodocus*, *Haplocanthosaurus*, *Supersaurus*. Appendicular and axial elements directly comparable to the *Brachiosaurus* holotype are herein described and discussed. The new material is comprised of mostly disarticulated elements consisting of six cervical, five dorsal, five fused sacral with three articulated caudal vertebrae and ilia, plus a scapulocoracoid. Based on a number of morphological differences, the DMDQ brachiosaur is not referable to *B. altithorax* and suggests the presence of a new species of Morrison Formation *Brachiosaurus* to be named elsewhere. Strong cervical vertebral similarities are noted to the Tendaguru material and inform, for the first time, with actual bones instead of supposition, the neck shape of a North American Late Jurassic brachiosaurid.

This study also reexamined the Potter Creek brachiosaurid material and concluded it is likely not referable to *B. altithorax*, nor the DMDQ taxon, based on vertebral differences and herein is here referred to *Brachiosaurus* sp., as are caudal vertebrae USNM 176354 and USNM 337935.

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Technical Session 19: Theropods - II (Saturday, October 21, 2023, 1:45 PM)

**SPINOSAURIDS CONVERGE WITH EXTANT CROCODYLIAN GENERALISTS IN TOOTH VARIABILITY: AN ANALYSIS OF HETERODONTY IN AQUATIC FORAGERS THROUGH ALVEOLAR DIMENSIONS.**

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Many lines of evidence suggest that members of Spinosauridae hunted aquatic prey. Although dental morphology can tell us crucial information about feeding in theropods, spinosaurid skull material is often fragmentary and in situ teeth are rare. This hinders trophic ecomorphological studies of this group. We use alveolar dimensions as a proxy for in situ teeth morphology to determine if there are meaningful differences in heterodonty that may be linked to diet. Spinosaurid alveoli were photographed parallel to the opening and were supplemented with figures of published specimens. With digitizing software, we derived the mesio-distal and labio-lingual distances of each alveolus and calculated the area of the opening as regular ellipse. *Angaturama* and *Irritator* did not have measurable alveoli. Instead, their mesio-distal distances were measured as the maximum length of in situ teeth and were assumed to be circular in cross-section. Heterodonty was calculated using a modification of Foote’s Morphological Disparity and plotted against size covariates. Similar data were collected from modern crocodylians from all three major extant clades. Results showed varying degrees of undulation in alveolar size along the arcade for all taxa, with heterodonty increasing in an allometric fashion ($R^2=0.910$, $p<0.001$). Where available, all spinosaurids had similar size variation in their mesial alveoli, suggesting similar methods of prey acquisition with the rostral-most dentition. Concerning distal alveoli, spinosaurines show enlarged 12th and 13th dentary positions whereas baryonychines have numerous, consistently-small alveoli. As robust distal dentition is correlated with processing large/hard food items, this suggests that spinosaurines consumed relatively larger prey that needed more extensive processing. These differences were not expressed by overall heterodonty though, as both clades had similar ranges of regression residuals. Crocodylian heterodonty displayed more distinct ecomorphological separation. Generalist crocodylians had undulating alveolar sizes and varied heterodonty residuals similar to spinosaurids, but *Gavialis* and *Tomistoma* had consistently low residuals and reduced size-undulations across their arcade; a consequence of consuming small, aquatic prey. These data suggest that although spinosaurids may have varied in the degree they processed food items, they did not exhibit as much as dietary variability modern crocodylians collectively do.

**Funding Sources** Daemen University

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Technical Session 12: Methods & Paleohistology (Friday, October 20, 2023, 8:00 AM)

**DETERMINANTS OF DENTINE GROWTH RATES ACROSS AMNIOTA**

D'Emic, Michael D.

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Teeth and associated tissues can reveal life history patterns and events on sub-daily-to-annual timescales in the form of incremental growth lines that are well preserved through fossilization. Dentine makes up the bulk of most teeth and grows by apposition, laying down growth lines of varying periodicities. To better understand the evolution of dentine growth rates, we compiled and a vetted dataset of nearly 150 amniote taxa, ca. 25% larger than that of a recently published study. We mapped daily dentine apposition rates onto a time-calibrated consensus phylogeny and reconstructed ancestral states using maximum likelihood. Ancestral state reconstruction reveals that regardless of diet, the earliest tetrapods and stem-mammals had mass-specific daily dentine growth rates that were substantially higher than those of the earliest reptiles. The mass-specific daily dentine growth rates of some ecologically specialized clades are exceptionally fast (e.g., notosuchian crocodylomorphs, rodents) or slow (e.g., primates, cetaceans). There is no relationship between daily dentine apposition rate and body mass—the range across the smallest species in our sample (< 1 kg) is approximately the same (ca. 1–20 microns/day) as that of the largest species (> 15,000 kg). Mass-specific resting metabolic rate shows no relationship with mass-specific daily dentine growth rate. Herbivores and faunivores have faster dentine growth rates than omnivores, and polyphyodont amniotes have substantially higher daily dentine growth rates than diphyodont amniotes, though these differences disappear when body mass is accounted for. Broadly, daily dentine growth rates do not differ according to habitat (semiaquatic/aquatic/terrestrial), whether or not body mass is accounted for. Phylogenetic generalized least-squares regression of our expanded dataset reveals that mass-specific daily dentine growth rate is a highly phylogenetically correlated character (Pagel's lambda ~ 1) strongly related to ecological and/or life history factors. Future work should sample a diversity of small-bodied amniotes as well as mammals with specialized dentitions to explore the limits of daily dentine growth rates.

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Technical Session 16: Theropods - I (Saturday, October 21, 2023, 8:00 AM)

**A GIANT TYRANNOSAUR FROM THE CAMPANIAN-MAASTRICHTIAN OF SOUTHERN NORTH AMERICA AND THE ORIGINS OF *TYRANNOSAURUS***

Dalman, Sebastian[1], Loewen, Mark[2], Pyron, R. Alexander[3], Jasinski, Steven E.[4], Malinzak, Dale[5], Lucas, Spencer[1], Fiorillo, Anthony[1], Currie, Philip J.[6], Longrich, Nicholas R.[7]

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Tyrannosaurid dinosaurs dominated as predators in the Late Cretaceous of Laurasia, culminating in the evolution of the giant *Tyrannosaurus rex*, both the last and largest tyrannosaurid. Where and when Tyrannosaurini (*T. rex* and kin) originated remains unclear. Competing hypotheses place tyrannosaurin origins in Asia, or western North America (Laramidia). We report a new, giant tyrannosaurid from the Campanian-Maastrichtian Hall Lake Formation of New Mexico, based on a fossil previously referred to *T. rex*. The new tyrannosaurid predates *Tyrannosaurus* by perhaps 6-7 million years yet overlapped with *Tyrannosaurus* in size. Phylogenetic analysis recovers the new tyrannosaurine as sister to *Tyrannosaurus* and suggests Tyrannosaurini originated in southern Laramidia before dispersing into Asia and the northern Great Plains. Evolution of giant tyrannosaurs in southern North America, alongside giant ceratopsians, hadrosaurs, and titanosaurs, suggests geographic patterns in body size evolution, with large-bodied dinosaurs evolving at low latitudes in North America.

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**ENCEPHALIZATION QUOTIENT (EQ) OF A MIDDLE MIOCENE SPARASSODONT (METATHERIA) FROM BOLIVIA**

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Metatheria is the clade including marsupials and their fossil relatives. During the Cenozoic, metatherians underwent a vast adaptive radiation, especially in South America, where nearly 30 families (most extinct) representing at least five orders have been identified. One well-known extinct metatherian group is Sparassodonta, a diverse clade of predatory mammals that has been the subject of many paleobiological studies. In contrast, knowledge of sparassodont paleoneurology is very limited. At present, endocasts of only two species have been described in the literature: the early Miocene borhyaenid *Borhyaena tuberata* and the Pliocene thylacosmiline proborhyaenid *Thylacosmilus*. In addition, a virtual cranial endocast (i.e., one constructed using computed tomography/µCT) of the early Miocene hathliacynid *Sipalocyon externus* was recently reported in a conference abstract. Here, we describe a virtual cranial endocast from a Miocene sparassodont from Bolivia, representing only the second virtual endocast generated for the group, and analyze its encephalization quotient (EQ), the ratio between expected and observed brain size relative to body mass. The specimen (UATF-V-001984) was collected at the early middle Miocene (Langhian) locality of Cerdas, southern Bolivia, and was provisionally identified as a new genus and species of borhyaenoid similar in size to the hathliacynid *Cladosictis patagonica*. It was scanned using the Inveon-PET-CT scanner at the Case Center for Imaging Research, and a 3D model of the cranium (including a virtual endocast) was constructed using Slicermorph. We calculated the endocranial volume at 12.65 cc, resulting in EQs of 0.23 and 0.45 using Jerison's equation and body mass (BM) estimates of 11 kg (based on lower molar row length/LMRL) and 4 kg (based on occipital condyle width/OCW), respectively. These EQ values span the range of EQs reported for *Borhyaena* and *Sipalocyon* (0.39 and 0.32-0.41, respectively) but suggest that BM is overestimated by LMRL. For *Thylacosmilus*, EQ values of 0.66-0.73 have been reported (for two endocasts), but these were based on BM values that are likely underestimates. We recalculated *Thylacosmilus* EQ values based on more recent BM estimates of 48-117 kg, resulting in new EQ values of 0.16-0.35, more similar to other sparassodonts (particularly higher values). Further study of this and other endocasts should provide insights into the paleobiology and phylogenetic relationships of sparassodonts.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**DINO JOHN DOE: UTILIZING OSTEOHISTOLOGY AND MORPHOMETRICS IN SPECIES IDENTIFICATION OF AN ISOLATED ORNITHISCHIAN TIBIA FROM THE LATE CRETACEOUS**

Danison, Andy[1], Heck, Christian[2], Flora, Holley[1], N. Woodward, Holly[1]

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Non-avian dinosaur species identification often relies heavily on gross morphological characters of cranial material. Ontogenetic changes and family-level conservation of post-cranial morphology limit the utility of the appendicular skeleton in species determination, particularly among Ornithopoda. However, appendicular bone microstructure preserves annually formed cyclical growth marks (CGM), which can be used to assess individual ontogenetic status and growth trends. Here, we utilize gross morphological measurements and cortical CGMs to investigate the taxonomic status of an isolated ornithischian tibia from late Cretaceous deposits in Montana.

A partial tibia was collected from the Campanian Two Medicine Formation at the Willow Creek Anticline locality in Teton County, MT. The Willow Creek Anticline locality is famous for the discovery and continued excavation of *Maiasaura* nesting and monodominant bonebed horizons. The partial tibia was found higher in section than the aforementioned horizons, and its pale coloration suggests it underwent different diagenetic processes than those fossils in the *Maiasaura* bonebed which appear dark brown or black. Osteohistological analysis of a mid-diaphyseal cross-section revealed five visible CGMs and age at death is estimated to be six years. Spacing

between successive CGMs suggests the individual was approaching skeletal maturity. The length:width ratio of the tibia is higher than ratios of the stockier ornithischian ankylosaurs and ceratopsians (e.g., *Einiosaurus*), but the tibia is more robust than that of a 10-year old *Maiasaura* and 14-year old *Probrachylophosaurus*, both hadrosaurs from the same time. Additionally, the growth curve of the unassigned tibia displays a higher annual growth rate than both *Maiasaura* and *Probrachylophosaurus*. Therefore, preliminary assessment of tibia morphology and osteohistology suggest either 1) the tibia represents an extreme variant of an already known contemporaneous hadrosaur, 2) the tibia originates from a non-contemporaneous ornithopod and, thus, extends the species temporal or geographical range, or 3) the tibia originates from a new ornithopod from the Two Medicine formation with stockier hindlimbs than contemporaneous species.

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Virtual Posters

**INTERRELATION OF RADIOCARBON AGES BONE FRACTIONS IN THE BRAZILIAN INTERTROPICAL REGION**

Dantas, Mário[1], Cherkinsky, Alexander[2]

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There is a consensus in the literature that radiocarbon dating performed on bioapatite ($^{14}C_{bioapatite}$) is often younger than that performed on collagen ($^{14}C_{collagen}$); thus, we propose a general regression that could be used to convert the $^{14}C_{bioapatite}$ to the simulated ages on collagen in fossil samples worldwide. We used 28 published results for a pair of collagen and bioapatite dates obtained from the same bone samples, with relatively good preservation. A reduced major-axis regression was produced using the entire sample to create a general regression. The radiocarbon-dated samples came from different countries located in boreal, temperate, subtropical, and tropical climatic zones, which altered the bioapatite and provided, in general, younger bioapatite radiocarbon ages than the collagen ones from the same samples. The general regression is $\log_{10}{}^{14}C_{collagen} = 1.09*\log_{10}{}^{14}C_{bioapatite} - 0.31$, it presents several good indices of quality, high correlation ($R^2 = 0.98$, $p < 0.05$), lower values of percent predicted error (%PE = 0.01), and standard error of the estimate (%SEE = 21.83), showing that it is a good tool, as the predicted values are similar to those observed. The radiocarbon calibration curve could allow the estimation of the age of terrestrial samples to approximately 50 kyr, which is the limit of the method, thus our regression should be used to convert only $^{14}C_{bioapatite}$ to ~39,400 yr. Older converted collagen dating could not be calibrated in the CALIB 8.1 program because of the extrapolation of the limit of 50 kyr. Using this regression, we converted the radiocarbon ages of bioapatite to the expected age from the collagen fraction of eight taxa from the Brazilian Intertropical Region (BIR). Later, they were calibrated into calendar ages before the present, using the same standard error found in the $^{14}C_{bioapatite}$, using the CALIB 8.1 program, and SHCal20 curve. Through the correction, we estimated that these dates could be 1-7 Cal BP kyr older than previously thought. Thus, until now the megafauna of the BIR brings paleoecological information of a time span ranging ~12,700 to 42,100 years and allows us to suggest that these meso-megamammals lived in the BIR, at least, until 12 kyr, in the late Pleistocene.

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Technical Session 17: Afrotheria & Mammal Macroevolution (Saturday, October 21, 2023, 8:00 AM)

**A TAXONOMIC REVIEW AND CHRONOLOGIC CORRELATION OF THE FOSSIL ASSEMBLAGE FROM THE MISSION PIT LOCALITY (CLARENDONIAN), SOUTH DAKOTA**

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The Mission Pit local fauna is a taxonomically diverse Clarendonian fossil assemblage from Mellette County, South Dakota that needed a full taxonomic revision and temporal correlation. Eleven macro-mammalian families are represented, namely members of the Equidae, Canidae, Camelidae, Rhinocerotidae, and Amphicyonidae. This assemblage is particularly notable for its abundance of isolated equid cheek teeth. These teeth, and other isolated elements from a variety of mammalian taxa, were identified using contemporary taxonomic diagnoses. Morphological analysis of taxa present and comparison to other Clarendonian-aged faunas from the Great Plains strongly suggest that the

Mission Pit local fauna accumulated in the second phase of the Clarendonian NALMA, (Cl2). Lines of evidence for this temporal placement include derived dental morphology of the amphicyonid *Ischyrocyon gidleyi* and the presence of the hipparionine equids *Pseudhipparion gratum* and *Neohipparion affine* as well as the borophagine canid *Aelurodon taxoides*. When compared to other Great Plains fossils assemblages the Mission Pit fauna compares most favorably using a cluster analysis in PAST software to the Minnechaduza fauna of Nebraska (Cl2). These results add to our collective knowledge of Great Plains biochronology and provide data usable in future studies.

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**THREE-DIMENSIONAL RANGE OF MOTION ANALYSIS IN *TYRANNOSAURUS REX* FORELIMB**

Davila, Ryan[1], O'Connor, Jingmai[1], Ma, Yubo[2], Sullivan, Corwin[2]

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Despite their iconography, the forelimbs of the *Tyrannosaurus rex* remain enigmatic in both their function and origin. Their stout build doesn't allow for extended reach, making conventional manipulation of their environment and prey unlikely. However, the forelimbs do show pathologies indicating repetitive use, further muddying the water on their perceived function or lack thereof. Given the increasing prevalence of modern computed tomographic (CT) techniques and 3-Dimensional modeling in paleontology, new avenues of quantitative analysis beget opportunities to further pursue the question of their functionality. FMNH PR2081 (aka SUE) preserves one of the most complete known *T. rex* forelimbs, which provides the opportunity to quantitatively explore range of motion. To do so, CT scans of the preserved forelimb elements were rendered into Maya and pivots were attached to represent the glenohumeral joint, the humeroradial joint, and the ulnar joint. Rigging of these joints and movement animations provide the basis for the musculature to be modeled in Software for Interactive Musculoskeletal Modeling (SIMM). The musculature itself is inferred based on previous modelling (Carpenter and Smith 2001) with comparative features to both *Crocodylus porosus* (Klinkhamer et al. 2017) and *Gallus gallus domesticus*. This technical approach to myology and kinesiology allows a quantitative assessment of the range of motion of the *T. rex* forelimb. This data can be used to assess existing hypotheses regarding forelimb function in this clade.

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Technical Session 2: Early Mammals & Carnivora (Wednesday, October 18, 2023, 8:00 AM)

**REINTERPRETATION OF THE DENTITION AND LOWER JAW OF THE ENIGMATIC BURROWING MAMMAL *FRUITAFOSSOR* BASED ON NEW MATERIAL FROM THE UPPER JURASSIC MORRISON FORMATION (GRAND COUNTY, UTAH, USA)**

Davis, Brian M., Rougier, Guillermo W., Connelly, Brigid E.

University of Louisville, Louisville, Kentucky, United States

Mammals underwent major diversification across many lineages during the Middle–Late Jurassic, including the likely origin of Theria. Far from limited to tiny, terrestrial insectivores, even early-diverging groups expanded into specialized ecological niches including semi-aquatic, arboreal, fossorial, and gliding forms. The Upper Jurassic Morrison Formation has perhaps the richest and best-studied terrestrial ecosystem from this interval, yet continued collecting efforts show we have much to learn. Since its discovery in 2015, the Cisco Mammal Quarry in Grand County, Utah has yielded a variety of well-preserved small vertebrate fossils. Mammals are particularly well represented in the current sample, including a morganucodontan, multituberculates, eutriconodontans, dryolestoids, and an exceptional new specimen of the basal mammal *Fruitafossor*. This taxon is known by just two other specimens from the nearby Fruita Paleontological Area in Colorado. It has forelimbs that are well adapted for burrowing, and the holotype was interpreted with xenarthrous vertebrae and tubular teeth lacking enamel, inviting parallels with modern armadillos. The new specimen has a slightly crushed, 3D skull with both dentaries and portions of the postcranial skeleton. With another new specimen from the same locality, the overall proportions of the dentary, the shape and extent of the coronoid and angular processes, and the morphology of the postdentary region can be accurately described; all differ from the

original interpretation of the holotype. Most of the teeth are missing, but those preserved confirm the single, open-rooted morphology of the holotype throughout the tooth series. One additional tooth is present in the lower dentition of the new specimen; the ultimate molar is substantially smaller than the penultimate tooth and is possibly absent in the holotype. Most importantly, the preserved lower cheek teeth bear enamel with cusps organized into a triangle: a tall buccal cusp with lower lingual cusps, typical of many mammaliaform groups with reversed triangles. Abrasion to the best-preserved crown implies embrasure occlusion with the upper molars. While the persistence of open roots suggests continued growth, the cheek teeth in *Fruitafossor* erupted with complex crowns, permitting closer comparison of tooth morphology with other Mesozoic mammaliaform lineages and a clearer picture of the phylogenetic context in which the ecological specializations of this taxon emerged.

**Funding Sources** Canyonlands Natural History Association (BD)

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Paleontological Management Poster Session (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**THE UTAH STATE PALEONTOLOGICAL LOCALIYTY DATABASE - USING COMPUTER TABLET APPLICTIONS FOR THE COLLECTION AND COMPILATION OF PALEONTOLOGICAL LOCALITY DATA**

DeBlieux, Donald D.[1], Kirkland, James I.[1], Hayden, Martha[1], Fasselin, Rosemary[1], Jensen, Martha[2], Anderson, Zachary[1], Sears, Ben[1]
[1]Utah Geological Survey, Salt Lake City, Utah, United States, [2]Bureau of Land Management, Salt Lake City, Utah, United States

To preserve and protect paleontological resources in the state of Utah, the Utah Geological Survey (UGS) has developed and maintained the Utah State Paleontological Locality Database (UPLD). To access locality data, we have relied upon partnerships and cooperative agreements with state and federal land management agencies, private landowners, paleontological consultants, and researchers working in the state. The database, begun over 30 years ago as a compilation of paleontological localities from published literature, currently includes over 25,000 unique localities. Until recently, this data was maintained in a Microsoft Access Database linked to an ArcGIS map project that displays fossil locality data in relation to other data layers, including topographic, geologic, and land-ownership data. This system limited the addition of data from disparate formats from our partners. Therefore, site data had to be laboriously entered by hand. To increase efficiency, we have migrated the UPLD to a geodatabase hosted on ArcGIS Online (AGOL). For the collection of field locality data, we partnered with the Bureau of Land Management (BLM) to develop a system using Apple iPad tablets and Esri's Field Maps (formerly Collector) App. The applications have several advantages including the ability to sync field data directly to AGOL as soon as an internet connection is available, reducing post-fieldwork data input and errors commonly introduced during that process. We have found that using tablets to collect locality data has many benefits. Prior to fieldwork, aerial imagery, topographic, and other maps can be side loaded onto the tablet to be used in areas without cellular coverage. The integrated GPS tablets give a real-time GPS location on the loaded basemaps, which is especially useful when navigating in backcountry areas and is a valuable aid when trying to relocate sites. Locality data is collected on a form that we created based on the information on the UGS and BLM locality forms. Many of the fields are in the form of drop-down lists to make collection easier and to improve the accuracy of data queries. We have been field testing the tablets and apps successfully during paleontological inventory projects on BLM and National Park Service (NPS) lands throughout Utah. The successful partnership between the BLM, NPS, and the UGS highlights the value of cooperation between state and federal land management agencies.
**Funding Sources** Bureau of Land Management, National Park Service, Utah Geological Survey

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Symposium Session: Theropod Flight Origins (Thursday, October 19, 2023, 1:45 PM)

**FUTURE DIRECTIONS IN THE STUDY OF THEROPOD FLIGHT ORIGINS**

Dececchi, Thomas A.[1], (23 authors), International Pennaraptoran Dinosaur Symposium 2 Peer Group[2], Pittman, Michael[3]

[1]Biology, Dakota State, Madison, South Dakota, United States, [2]International Pennaraptoran Dinosaur Symposium, Shatin, Hong Kong, [3]School of Life Sciences, The Chinese University of Hong Kong, Shatin, Hong Kong

In the past three decades a flood of new fossils, technologies and approaches has revolutionized the study of flight origins within paravian dinosaurs. This has led to a quandary: how it is that when we seem to be flooded with fossils, does it seem we are in many ways less certain of key components of this event than before, including where and when it occurred and whether it occurred more than once. Here we will present a consensus view established during a discussion-focussed meeting in Hong Kong about the future of theropod flight origins research. This covered three aspects. Firstly, the need to define and delimit prolonged aerial behaviors (i.e., extended jumps, controlled flapping descent) and their grading into what we classify as "flight", and the need to specify occasional vs habitual behaviors to categorize ecomorphospace. This is expected to improve our ability to evaluate new discoveries and evolutionary hypotheses. Secondly, we documented key missing data such as knowledge of anatomical variation, but also noted what we can't know based on limits to fossil inference e.g., joint capsule anatomy. Thirdly, we took stock of methods and modelling currently available and that should be developed moving forward, including methods that can better integrate extant data and examine multimodal locomotion and newer areas such as robotics. This allowed us to hone in on major questions we can, and importantly, cannot resolve regarding flight origins and how do we best approach major remaining uncertainties in the field. This includes more fine-scale aspects such as using methodologies that can examine important and under studied details e.g., does using estimates of atmospheric density and aerodynamic airflow alter our reconstruction of flight potential and performance across the Mesozoic? A need to redefine key problems was noted particularly in moving away from over-simplistic dichotomies of how flight evolved e.g., ground up vs tree down, powered vs non-powered flight). Common language, approaches and criteria across our field will lead to greater insights through a more systematic and holistic approach that will facilitate integration between research groups and with other disciplines. As we enter the next phase in the study of flight evolution, we need a more coordinated approach to ensure move from "just so" stories to testable hypotheses.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**AN EXCEPTIONALLY YOUNG JUVENILE CF. *BOTTOSAURUS HARLANI* SPECIMEN FROM THE MAIN FOSSILIFEROUS LAYER OF THE CRETACEOUS-PALEOGENE HORNERSTOWN FORMATION AT THE EDELMAN FOSSIL PARK IN MANTUA TOWNSHIP, NEW JERSEY**

Deckhut, Joseph T., Boles, Zachary

Rowan University, Glassboro, New Jersey, United States

A small left dentary and two isolated teeth were recently collected from the Main Fossiliferous Layer (MFL) of the Hornerstown Formation at the Jean and Ric Edelman Fossil Park in Mantua Township, New Jersey. The teeth are mediolaterally compressed in cross-section, blunt and robust, and display wrinkled enamel with basoapically aligned striations as well as mesial and distal carinae, which are characteristic of the taxon. The dentary is fairly well preserved with an intact mandibular symphysis. The splenial closely approaches the mandibular symphysis without contributing to it and the splenial also has the anterior tip pass dorsal to the Meckelian groove as in *Bottosaurus* and *Borealosuchus*. The mandibular symphysis extends to about the 4$^{th}$ or 5$^{th}$ alveolus. 11-12 alveoli are preserved with the posterior alveoli being the largest. The associated teeth appear to be the correct size to have been from this region of the jaw. There is a gentle curve extending between the ?4$^{th}$ and ?10$^{th}$ alveolus. Of the crocodilians known from the MFL, only *Bottosaurus harlani* and *Borealosuchus threeensis* have jaws that are similar in overall morphology to this specimen. We tentatively assign this specimen to *Bottosaurus harlani* based on the overall robustness of the dentary and the assumption that the teeth truly belong to the same individual. Thus, this specimen represents the smallest and youngest known individual of this taxon.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**A NEW PLATYNOTAN LIZARD (SQUAMATA, ANGUIMORPHA) FROM THE LATEST CRETACEOUS (MAASTRICHTIAN) OF NORTH AMERICA**

DeMar, David G.[1], Bennett, George[2]

[1]Burke Museum, Seattle, Washington, United States, [2]Virginia Museum of Natural History, Martinsville, Virginia, United States

Platynotan lizards (helodermatids, varanids, and their closest relatives) are a conspicuous faunal component of Late Cretaceous nonmarine ecosystems of the Western Interior of North America. Four named genera are known from this area during the latest Cretaceous (Maastrichtian) including *Parasaniwa*, *Palaeosaniwa*, *Paraderma*, and *Cemeterius*. At least two novel platynotans have come to light based on our collection and investigation of specimens from the Hell Creek and Lance formations of Montana and Wyoming, USA. Here we present one of these new platynotans. Historically, parietals and/or squamosals of this taxon were attributed to non-platynotan lizards (e.g., *Exostinus lancensis*) and a pachycephalosaur dinosaur. Our new evidence, however, clearly demonstrates playnotan affinities. The new taxon is unique among Late Cretaceous platynotans from the Western Interior in featuring a cranial and osteodermal ornamentation of rounded to angular, high-relief nodes with numerous pores; all others have relatively low-relief ornament. Based on the shared presence of the nodose ornamentation, we have attributed additional elements to this taxon including a premaxilla, maxillae, frontals, isolated osteoderms, and, tentatively, a jugal. Importantly, the maxillary teeth lack resorption pits and have expanded bases with basal infolding of their enamel and dentine into the pulp cavity (plicidentine), all diagnostic features of Platynota. Our cladistic analysis supports this hypothesis in recovering the taxon on the stem of Varanoidea. Other notable anatomical features include fused premaxillae, paired frontals each with three parallel rows of nodes, retracted nares, a broad parietal table, a squamosal with posteriorly pointed nodes along its posterior margin, and thick, non-imbricating osteoderms with sutural margins and an enlarged, keeled central node. Reconstruction of the skull indicates a skull length of approximately 50–60 mm, which is moderately large for a Maastricthian-age lizard from North America; the largest contemporaneous platynotan was *Palaeosaniwa* (~100 mm skull length). In the Hell Creek Formation of Garfield County, Montana, where we have collected from a dense sequence of vertebrate microfossil localities, elements of the new taxon occur throughout most of the stratigraphic thickness of the formation. As with all other Hell Creek platynotans, it did not survive the end-Cretaceous mass extinction.

**Funding Sources** NSF GRFP (DGE-0718124), UCMP Doris O. and Samuel P. Welles Research Fund, and the Myhrvold and Havernack Charitable Foundation.

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Romer Prize Session (Thursday, October 19, 2023, 8:00 AM)

**GETTING BACK TO OUR ROOTS: WHAT TOOTH ROOT NUMBER CAN TELL US ABOUT THE ECOLOGY AND PHYLOGENY OF FOSSIL MAMMALS**

DeMers, Anessa

Evolution, Ecology, and Organismal Biology, The Ohio State University, Columbus, Ohio, United States

The mammalian tooth root has many features that could make it an appealing source of phylogenetic and ecological information for fossil taxa: it is functionally critical, serving to anchor the tooth and distribute stress from mastication; it is morphologically variable, including in easily measurable ways such as root number; furthermore, it is a mineralized structure that fossilizes well both on isolated teeth and within fossil jaws. Despite these useful features, however, the tooth root is often ignored. Part of the reason for this neglect is that we have previously lacked a broad understanding of what root morphologies exist in extant and extinct mammals and what drives this diversity. To make root morphology a more practical source of phylogenetic and ecological information for fossil mammals, I sought to investigate whether there is a simple underlying factor, such as diet or tooth dimensions, that explains the number of roots on mammalian teeth. Here, I present data from an exploratory survey of tooth root number for the mandibular and maxillary dentitions of over 400 species, including all extant mammalian orders and select extinct taxa from the Cretaceous through the Quaternary. I identify an ancestral mammalian pattern for root number as well as major deviations from this pattern that can help identify group affinities for fossil taxa and possible instances of convergence. I find that changes to the root number of the anterior teeth are almost unknown, with consistent single-rootedness seen in the incisors and repeated evolutionary reductions in root number at the canines. The cheekteeth, in contrast, show high variability in root number, having from one root to five or more. Root number is highly conserved in most lineages, but there has been repeated evolution of root number variability across Mammalia at several different tooth positions. Similarly, I find that intraspecific variation tends to be concentrated at species-specific tooth positions, hinting at underlying developmental constraints. Both diet and crown morphology can be linked to deviations in root number, but root number variation as a whole defies simple explanation. Instead, I find root number to be characterized by a common pattern with repeated, distinct departures in the modern era and in fossil mammals throughout history.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**FIRST RECORD OF A TERRESTRIAL SNAKE (CF. *THAMNOPHIS* SP.) FROM THE CALVERT FORMATION (EARLY BARSTOVIAN, MIDDLE MIOCENE) OF MARYLAND, AND THE EARLIEST KNOWN OCCURENCE OF THE NATRICINE GENUS *THAMNOPHIS* IN NORTH AMERICA**

Denton, Robert K.

Geology, Terracon Consultants Inc., Ashburn, Virginia, United States

The Miocene Calvert Formation of the Coastal Plain of Delaware, Maryland and Virginia has a long history of producing a large number of taxa including cartilaginous and bony fish, amphibians, chelonians, crocodilians, and mammals, ranging in age from the early Hemingfordian to the late Barstovian NALMA (20 Ma - 13 Ma). However, the only terrestrial snakes previously known from the Calvert were taxa of boids, colubrids and viperids from the Hemingfordian fauna of the Pollack Farm Site in Delaware.
We here report the discovery of a series of well-preserved thoracic vertebrae, caudal vertebrae, and ribs, identified as an indeterminate species of the natricine genus *Thamnophis* (i.e., Garter Snakes and Ribbon Snakes). The associated remains were found by an avocational paleontologist in a stream exposure near Waldorf Maryland, dated on the basis of the diagnostic molluscan fauna as Shattuck Zone 10 of the early Barstovian Plum Point Member of the upper Calvert Formation. It is of note that this is the first record of a terrestrial snake from the Calvert Formation of Maryland and may be the oldest verified occurrence of the genus *Thamnophis* from North America. The oldest previous record of *Thamnophis* is an isolated thoracic vertebra from the Miocene Egelhoff Site of North-Central Nebraska, dated to the medial Barstovian on the basis of the site's mammalian fauna.

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Technical Session 8: Mammal Paleoecology (Thursday, October 19, 2023, 1:45 PM)

**THE PLIO-PLEISTOCENE IS A CLEAR DEPARTURE FROM THE PRESENT: ECOLOGICAL SHIFTS EVIDENCED FROM FAUNA AT THE DARLING DOWNS, QUEENSLAND, AUSTRALIA**

DeSantis, Larisa[1], Price, Gilbert J.[2], Louys, Julien[3]

[1]Department of Biological Sciences, Vanderbilt University, Nashville, Tennessee, United States, [2]University of Queensland, Brisbane, Queensland, Australia, [3]Griffith University, Brisbane, Queensland, Australia

The continent of Australia is currently warming approximately thirty-five percent faster than the rest of the globe, with the warmest year on record coinciding with the most extreme bush fires. While effects of ongoing climate change are apparent over the past century, Australia has experienced pronounced aridification since the late Miocene/early Pliocene, transitioning from tropical forests to more open habitats. To better contextualize on-going climate change, we assess the ecology and paleobiology of mammalian faunas in Australia from the Pliocene to the Present in the Darling Downs region of Queensland Australia. Via the analysis of stable isotopes from tooth enamel and dental microwear texture analysis of the chewing surfaces of teeth, we clarify the ecology and paleobiology of medium to large marsupials from the Pliocene Chinchilla Sands and Pleistocene Eastern Darling Downs faunas. By comparing these ancient marsupial mammal communities to extant marsupial mammals that inhabit these regions today, we further demonstrate that the most dramatic changes between past ecosystems are clearly between those of the Present and the Plio-Pleistocene—indicated that the Darling Downs region of today is disparate as compared to the past. Most notably, *Macropus giganteus* consumes vegetation that is ~5.6‰ higher in $\delta^{13}C$ values today than during the past, indicating feeding in a significantly more open landscape. The Pliocene and Pleistocene of the Darling Downs are instead dominated by mixed-feeding and browsing taxa, with several taxa exhibiting diets disparate from modern analogues (e.g., an abundance of $C_4$ browsers). Collectively, these deep-time temporal comparisons are a clear example of how ecological communities observed today do not represent the full range of ecological niches occupied in the past and

highlight the dramatic climate-departures experienced today.

**Funding Sources** National Science Foundation and Vanderbilt University.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**REPTILES AND MAMMALS AND FISH, OH MY: DIGITIZATION OF THE SCIENCE MUSEUM OF MINNESOTA'S PALEOCENE WANNAGAN CREEK COLLECTION FROM NORTH DAKOTA**

DeVault, Grace[1], Hastings, Alexander K.[1], Iverson, Charlie[2]

[1]Paleontology, Science Museum of Minnesota, St Paul, Minnesota, United States, [2]Science Museum of Minnesota, St Paul, Minnesota, United States

The Science Museum of Minnesota recently initiated digitization of its paleontology collection, beginning with more than 15,000 specimens collected between 1970 and 1996 from in and around the 60 million year old Wannagan Creek quarry in western North Dakota. Due to its temporal and geographic proximity to a large amount of material immediately predating the end-Cretaceous mass extinction, this collection represents an excellent look into the recovery of life after that traumatic event. The collection includes a wide variety of vertebrates, invertebrates, and plants. However, much of this collection remains unknown to the scientific community, as most records previously existed only as paper documents. The current digitization project aims to greatly increase accessibility of the collection so that it can be a valued resource for the paleontology community and the general public.

Although diversity in the Wannagan Creek collection is high, much of its quantity comes from a single crocodyliform, *Borealosuchus formidabilis*. Other reptiles include an alligatoroid, a champsosaur, squamates, and several species of turtle; mammals include carnivorans, ‘condylarths,’ marsupials, an erinaceomorph, viverravids, multituberculates, pantolestids, pentacodontids, primates, a proteutherian, a possible rodent, and soricomorphs; birds include *Dakotornis* and *Presbyornis*; amphibians include anurans and scapherpetontids; osteichthyans include acipenseriforms, lepisosteiforms, amiiforms, osteoglossiforms, and salmoniforms; chondrichthyans include batoideans; and non-vertebrate material includes insects, gastropods, bivalves, trace fossils (trackways, burrows, and coprolites), fungi, and a diverse collection of flora. So far, ten new taxa have been erected from Wannagan fossils, including two crocodyliforms, one turtle, one bird, one plant, one dragonfly, two burrow ichnotaxa, and two footprint ichnotaxa.

The digitization project surrounding this collection involves the entry of each specimen’s information into an institutional database, photography of each specimen, plus rehousing and preparation of specimens as needed. Information and photos are being made available through iDigBio and eventually through the museum’s website. To date, over 5,770 specimens have been digitized. The end goal of this project is to make this entire valuable collection accessible online, and to bring the research potential of this collection to light.

**Funding Sources** This work was funded by the Institute of Museum and Library Services Grant MA-249382-O.

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Technical Session 1: Sauropod & Ornithischian Dinosaurs (Wednesday, October 18, 2023, 8:00 AM)

**SMALL-BODIED ARMORED DINOSAUR FROM NIGER (IRHAZER SERIES: TIOURARÉN FORMATION) DOCUMENTS THE BASAL ACQUISITION OF QUADRUPEDAL POSTURE AND SUBADULT HERDING BEHAVIOR AMONG THYREOPHORANS (DINOSAURIA: ORNITHISCHIA)**

DeVries, Raina P.[1], Sereno, Paul C.[1], Gamonal, Arturo[2], Fontela, Noelia S.[3]

[1]Organismal Biology & Anatomy, University of Chicago, Chicago, Illinois, United States, [2]Museo Paleontológico de Alpuente, Alpuente, Valencia, Spain, [3]Geology, University of Oviedo, Oviedo, Asturias, Spain

A herd of over twenty individuals of a new, small-bodied, armored ornithischian came to rest in a circumscribed mud deposit about one meter in depth in the Tiourarén Formation of Niger. The almost monospecific, fine-grained deposit also includes partially articulated remains of the caudal fin skeleton of the coelacanth *Mawsonia*. Found in close

proximity to the overbank deposits were articulated remains of the sauropod *Jobaria*, the theropod *Afrovenator,* and other vertebrates. The majority of the mostly disarticulated thyreophoran material is subadult, with no hatchling and few adult bones among the thousands interred in the deposit. For the site and its preserved fossils, we infer a mass catastrophic event with minimal post-event transport that rapidly buried an immature herd of thyreophorans.

The best-preserved bones of the thyreophoran, including one articulated partial skeleton, were CT-scanned, then digitally restored and assembled in *Blender* and *ZBrush* to create a complete skeleton. The resulting nearly mature subadult skeleton was reconstructed as an obligate quadruped with a length of 135 cm (trunk max height 35 cm, femur length 11 cm, tibiofemoral ratio 1.3). The narrow and small-snouted skull bears a handful of thyreophoran synapomorphies but otherwise generally resembles the condition of the basal ornithischian *Lesothosaurus*. Relatively long cervical vertebrae support and elevate the skull. Both forelimb and hindlimb are digitigrade with bound metapodials. The manus features derived hoof-shaped unguals. Long sacral ribs and a flattened, laterally-curving preacetabular process increase the girth across the hips. The armor is composed predominantly of isolated parasagittal osteoderms and includes a wide variety of keeled scutes, some raised into blades as tall as 3.5 cm. We reconstruct an obligate quadrupedal posture based on a range of features including the bound metacarpus, hoof-like manual unguals, broad pelvis, midshaft femoral fourth trochanter, and estimated posterior trunk position of the center of body mass. With a phylogenetic position basal to *Scelidosaurus* and eurypodans, this new African thyreophoran suggests that obligate quadrupedal posture in armored ornithischians was acquired at small body size.

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Technical Session 10: Euarchontoglires & Xenarthra (Friday, October 20, 2023, 8:00 AM)

**RECONSTRUCTION OF DIETARY EVOLUTION IN NEW WORLD PRIMATES (PLATYRRHINI) BASED ON DENTAL TOPOGRAPHIC ANALYSIS OF EXTANT AND FOSSIL SPECIES**

de Vries, Dorien[1], Batista, Romina[1], Maugoust, Jacob[2], Boubli, Jean[1], Goodhead, Ian[1], Beck, Robin M.[1]

[1]School of Science, Engineering, and Environments, University of Salford, Salford, United Kingdom, [2]Institute of Evolutionary Science of Montpellier, University of Montpellier, Montpellier, France

Modern New World primates (Platyrrhini) exhibit a diverse range of diets, including folivory, omnivory, seed predation, and exudate feeding. Numerous fossil platyrrhines are known, but predictions of their diet remain controversial, and the overall pattern of dietary evolution (particularly the number and direction of transitions between diets) within Platyrrhini as a whole remains unclear. We developed a revised 5-category dietary classification for platyrrhines based on data extracted from 92 published studies, and we used dental topographic metrics calculated via a novel freeware pipeline to quantify second lower molar shape of a large comparative sample of platyrrhines covering 32 genera (20 extant, 12 fossil) and 44 species (31 extant, 13 fossil), totaling 161 specimens (1-10 specimens per extant species, 1-2 specimens per fossil species). Using our extant platyrrhine sample as a training set, we used a Quadratic Discriminant Analysis (QDA) on specimen values and a phylogenetic flexible discriminant analysis (pFDA) on species averages to classify the fossil taxa into one of five dietary categories. Consistent results across both methods showed that, for example, *Proteropithecia* and *Cebupithecia* were classified as seed predators, confirming previous hypotheses, and that the stem alouattine *Stirtonia* was classified as a frugivore, unlike it being a folivore as proposed in previous studies. However, differences in reconstructed diets between the two methods include, for example, *Neosaimiri* being classified as a frugivore-insectivore in the QDA, but as a seed predator in the pFDA. The inferred diets of 12 fossil platyrrhine genera provide key new evidence for understanding dietary evolution of Platyrrhini. Our results allow us to identify transitions in the diets of New World primates, which can be compared against genomic evidence of dietary evolution, as well as to assess methodological differences between our analyses, which are highly relevant to researchers using discriminant analysis to infer the paleoecology of extinct species.

**Funding Sources** This project was supported by funds from the Natural Environment Research Council (NERC NE/T000341/1).

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**A NON-OTOLITH, ACANTHOMORPH FISH SPECIMEN FROM THE COON CREEK FORMATION (LATE CRETACEOUS: MAASTRICHTIAN) OF MISSISSIPPI, USA**

DeWees, Zoe, Jackson, Hayden, Fielitz, Christopher

Biology, Emory and Henry College, Emory, Virginia, United States

The Late Cretaceous Coon Creek Formation of western Tennessee and northeast Mississippi is known for its diverse fauna of invertebrates as well as vertebrates such as chondrichthyans, teleost fishes, turtles, plesiosaurs, and mosasaurs. Among the teleost fishes, the acanthomorph fishes of the Coon Creek Formation that include the Holocentridae, Apogonidae, Trachichthyidae, and Bathyclupeidae are known only by otoliths. A specimen housed at the Mississippi Museum of Natural Science (MMNS VP-6195) is the first record of an acanthomoph fish that is not an isolated otolith. It consists of a nearly complete skull roof, fragments of the upper and lower jaws, opercular bones, a cleithrum, as well as the anterior portion of the trunk with scales. A series of serrated ridges run along the lateral edges of the parietals and pterotics. Serrated edges are also present along the posteriors of the deep opercle and cleithrum. The upper and lower jaws are poorly preserved but a single, ornamented supermaxilla is observed. Ctenoid scales are present on the body but none are isolated. The lack of a large supraoccipital rules out several groups including the Apogonidae and the Holocentridae. The characteristics point to possible relationships to *Ctenothrissa*, *Aulolepis*, or *Hoplopteryx*.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**TRIDACTYL FOOTPRINTS REFERABLE TO *ANOMOEPUS* SP. FROM THE LATE JURASSIC-EARLY CRETACEOUS MIST MOUNTAIN FORMATION OF SOUTHEASTERN BRITISH COLUMBIA**

Dickson, Logan T.[1], Arbour, Victoria[2]

[1]School of Earth and Ocean Sciences, University of Victoria, Shawnigan Lake, British Columbia, Canada, [2]Royal BC Museum, Victoria, British Columbia, Canada

Two large blocks containing tridactyl footprints from the Fernie, British Columbia area remained tucked away in the basement of the Royal British Columbia Museum for several decades. One block contains a single partial imprint while the other contains three well-preserved natural casts, some of which have skin impressions. These footprints were collected from the Fording River Operations coal mine near Elkford in southeastern British Columbia. This mine collects from the Mist Mountain Formation, which is a sequence of interbedded sandstone, siltstone, and mudstone with seams of bituminous and semianthracite coal. This formation is representative of a period of repeated transgression and regression of the epeiric Fernie Sea during the Late Jurassic to Early Cretaceous. Previously documented dinosaur footprints from Elk Valley coal mines include sauropods as well as small to large ornithopods and theropods. We used traditional morphometrics to compare our footprints to other tridactyl ichnogenera from the Jurassic-Cretaceous boundary, and digitally modeled the footprints to generate false depth maps and isolines to define their outlines which we used to take measurements of interdigital angles and the anterior triangle. The footprints are 20.4-21.9 cm long and have wide interdigital angles, a high width to length ratio, and an anterior triangle length to width of 0.48-0.51. The prints lack sharp claw impressions. Digital pads are distinct and separated by double creases. Overall, these characteristics point to a small ornithischian trackmaker, possibly a small ornithopod, and the presence of double creases between the digital pads is diagnostic for the ichnogenus *Anomoepus*. Similar small-to-medium ornithopod tracks have previously been identified from the Fording River Operations mine, but all lack double creases and are referable to the ichnogenus *Neoanomoepus.* This indicates that there were at least two small ornithischians present in the Mist Mountain Formation of southeastern British Columbia during the Late Jurassic to Early Cretaceous.

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Technical Session 7: Birds (Thursday, October 19, 2023, 8:00 AM)

**NEORNITHINE RANGE RESPONSE TO PALEOGENE GLOBAL WARMING**

Dickson, Meig C.

Biology, New Mexico State University, Las Cruces, New Mexico, United States

Previous instances of dramatic climate change in Earth's history remain our primary point of comparison in order to understand anthropogenic climate change today. The Paleocene-Eocene Thermal Maximum (PETM) is the most recent instance of rapid warming similar to present conditions, and the reactions of mammal and plant groups to this event have been studied extensively. The response of birds, however, is poorly known. Modern day birds have shifted range as climates have warmed in the past epoch. As such, the ranges of birds before and after the PETM require examination for similarities to present behavioral patterns. Change in range is measured in a few ways: overall change in latitude and longitude, as well as change in median range position and overall range size across geologic ages. These changes are then correlated with climatic shifts as seen during the PETM. Records gathered from the Paleobiology Database were cross-referenced and compared across the Paleocene and Eocene epochs for all avian taxa. Expansion into higher latitudes is seen for the global avian range in this period. Furthermore, individual clades such as Sandcoleiformes or *Gastornis* and its relatives show expansions out of narrow ranges into new hemispheres. Range expansions across clades were accompanied by increases in taxonomic diversity and number of fossil occurrences. These changes seem to be unique to avian fossils and not reflective of global taphonomic trends, pending further study. This tentatively indicates that avian responses to rapid warming have remained similar across evolution through the Cenozoic, potentially due to increased average avian mobility via flight. Future work will look for other changes that may have accompanied range shift in birds during this climatic shift.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**PARDON MY PLASTER: REANALYSIS OF THE HISTORICALLY IMPORTANT APATOSAURINE SPECIMEN UW15556**

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UW15556, most recently identified by Tschopp (2015) as *Brontosaurus parvus*, is a historically important apatosaurine specimen discovered in Wyoming in 1901. Excavated by C.W. Gilmore from Sheep Creek Quarry E, it was originally housed in the Carnegie Museum collections (CM 563), where it was the subject of numerous papers, including Hatcher's 1902 description of the articulated forelimb of the specimen, the first known for a sauropod, and most notably Gilmore's 1931 beautifully figured monograph on the Carnegie Museum apatosaurines. In the mid-1900s, University of Wyoming Geological Museum curator negotiated its return to the state in a trade of some mammal fossils to the Carnegie in return for the specimen. It has been on display in the UW Geological Museum ever since. As a result of the early research focus on the specimen, which was then identified to Apatosaurus excelsus, the specimen became a common reference for the species and genus. Gilmore's figures have become a common reference for the anatomy of the specimen, however they often omitted the high level of reconstruction that many of the preserved bones have undergone, particularly the cervical and dorsal vertebrae. This has led to the specimen being assigned characters based on elements entirely composed of plaster in even the most recent phylogenetic studies that include it. Due to its historically and phylogenetically important status, it is imperative to fully assess the level of reconstruction and determine which phylogenetically important features are truly present. UW15556 also serves as an important reminder that Bone Wars era sauropod specimens warrant renewed physical investigation.

**Funding Sources** University of Wyoming Department of Geology and Geophysics

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Preparators' Poster Session (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**DETECTING EROSION AT THE ENGARE SERO HOMINID FOOTPRINT SITE, TANZANIA, AND IMPLICATIONS FOR *IN SITU* TRACKWAY CONSERVATION**

Dill, Vanya L., Zimmer, Brian, Marshall, Scott, Liutkus-Pierce, Cynthia

Appalachian State University, Morrisville, North Carolina, United States

Regardless of who or what made them, trackways and other trace fossils provide important paleobiological information that is not easily acquired from bones. However, trackways are difficult, sometimes impossible, to collect and often must be left *in situ*, where they are subject to degradation due to erosion. To compound the issue, the conditions that favor the preservation of tracks, such as fine grain size often correspond with those that make the tracks highly susceptible to erosion once uncovered. The more eroded a print becomes, the less reliable information extrapolated from it is. In this study we looked at the late Pleistocene Engare Sero footprint site in Tanzania, which is home to over 400 early hominin footprints. These prints provide insights into the physical stature and social groupings of the printmakers. Located in an ephemeral stream channel, the site floods on a regular basis. The frequent flooding of the site makes water-induced erosion a major concern for those researching and working to preserve the prints found here. A previous study (2010-2017) quantified the rate of erosion at three particularly well preserved prints and noted significant degradation during the study interval. Sometime between 2013 and 2015, an unknown party erected a stone and concrete wall and fencing system around the footprint site. Since the date of installation is unknown, the original study was unable to account for any influence of the wall on the erosion of the prints. The purpose of this study is to assess the efficacy of the wall and fence system in reducing erosion rates by keeping both people and moving water off the footprinted strata. For this study, we used images collected from the same three prints in 2017 and 2022 to photogrammetrically generate 3D models, which we then compared using point cloud comparison algorithms to identify areas of change. We selected this technique because it is a low-cost and non-invasive method to quantify erosion at any site, including those without permanent ground control points. The technique also maintains methodological consistency with the previous study. By comparing our results to the results of the previous study we aim to 1) determine if additional mitigation techniques are necessary for the long-term sustainability of the Engare Sero footprint site and 2) help conservationists decide whether strategically placed walls are actually an effective and cost-efficient way to reduce erosion at other vulnerable sites.

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Preparators' Session (Thursday, October 19, 2023, 8:00 AM)

**BONES TO BYTES: COMPUTED TOMOGRAPHY DATA PREPARATION AND VISUALIZATION STRATEGIES FOR LARGE, COMPLEX FOSSIL DATASETS**

Dougan, Lindsay G., Lessner, Emily, Petermann, Holger, Lyson, Tyler, Panigot, Eldon, Duffy, Franklin

Earth Sciences, Denver Museum of Nature & Science, Denver, Colorado, United States

Paleontologists often encounter massive clusters of bone encased in logistically difficult matrix that prove challenging for traditional mechanical preparation methods. Imaging methods such as computed tomography (CT) scanning allow for visualization of elements through digital preparation of such large, jacketed, unprepared, complex fossils. Here, we scanned a 0.75m$^3$, 550kg burlap-field jacket reinforced with wood 2X4's that contained an assortment of fossils. The specimen was scanned using a 6MeV system at the North Star Imaging facility in Aliso Viejo, California. The output data was provided as two datasets; 1) 350mm voxel size and 20.1GB file size; and 2) 244mm voxel size and 88.7GB file size. The lower-resolution dataset was useful for preliminary data review as a "scouting" dataset because it was less computationally demanding and contained sufficient detail for relating major and most minor skeletal remains in the fossil. The higher-resolution dataset provided more anatomical detail but required a unique, novel digital-preparation approach due to the large file size. We faced several challenges with the higher-resolution dataset that required adjustments to our standard workflow; the most-limiting factor was computational resources that made working simultaneously on the dataset with a larger team difficult. The full 89GB fossil dataset could not be opened on all workstations. To address this, we cropped the full dataset into eight 11GB orthogonal blocks. The bulk of segmentation work took our team of 10 over 5000 hours. We imported each discovered fossil element as a segmented Region of Interest (ROI) back into the full, uncropped 89GB dataset for final cleanup and 3D visualization. Here, we encountered issues with global coordinate positioning, realignment, and merging of fossil ROIs. We eventually solved these issues by importing each fossil ROI into the full dataset, resetting the coordinates as needed, and resampling geometry of the fossil ROI into the full dataset. To assist with 3D rendering and visualization we created mesh proxies for the matrix block and jacket. This eased the computational requirements for visualizing the final segmentation results. Our findings demonstrate the challenges and solutions for managing large fossil CT-datasets collaboratively, offering insights into potential solutions for improving the efficiency and accuracy of segmentation, meshing, and post-processing of large data sets.

**Funding Sources** National Science Foundation, National Geographic, Lyda Hill Philanthropies

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

### FIRST U-PB CA-ID-TIMS AGE CONSTRAINTS ON POLAR DINOSAURS FROM THE PRINCE CREEK FORMATION, NORTHERN ALASKA

Druckenmiller, Patrick S.[1], Johnson, Kirk[2], Ramezani, Jahandar[3], Tsukui, Kaori[3], McCarthy, Paul[4], Perry, Zackary R.[4], Flaig, Peter[5], van der Kolk, Dolores[6], Brown, Caleb[7], Erickson, Gregory M.[8]

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The Upper Cretaceous Prince Creek Formation (PCF) of northern Alaska is recognized as one of the most important units for understanding ancient polar terrestrial ecosystems in the Mesozoic. The PCF preserves a rich assemblage of avian and non-avian dinosaurs, mammals, and fishes. It was deposited at the northernmost extremes of Laramida, well above the paleo-Arctic Circle. By virtue of its geographic location, it provides key faunal and floristic data necessary to address broader questions concerning climatic regimes, faunal provinciality, and evolutionary patterns in Laramidia. Fundamental to such cross-latitudinal comparisons is precise correlation of continental successions across the Western Interior Basin (WIB). While recent high precision geochronological frameworks have been developed for important fossil-bearing formations at mid-latitudes in the WIB, comparable data from high latitude settings are lacking. Here we present new U-Pb zircon geochronology by the high-precision CA-ID-TIMS method from three bentonites interlayered with the most fossiliferous sections of the PCF along the lower Colville River, including just above the well-known Liscomb Bonebed. Our new dates range from 72.974 ± 0.019 Ma to 72.770 ± 0.048 Ma (2σ internal uncertainties) and constrain deposition of the fossiliferous portions of the PCF to the late Campanian—nearly 4 million years older than previous radiometric results (~69 Ma; early Maastrichtian). The fossiliferous portion of the PCF correlates with more southerly terrestrial successions including: 1) lower Unit 4 of the Wapiti Formation (west-central Alberta); 2) the *Edmontosaurus regalis-Pachyrhinosaurus canadensis* (73.1–71.5 Ma) dinosaur assemblage zone of the Drumheller Member of the Horseshoe Canyon Formation (southern Alberta); and 3) the uppermost Kaiparowits Formation (southern Utah). In east-central Montana, PCF deposition largely overlaps with the upper marine Bearpaw Shale. The newly recognized late Campanian age for the PCF fauna helps to better target appropriate age-equivalent units for cross-latitudinal faunal comparisons. Importantly, these findings augment the latitudinal range of known Campanian dinosaurs, which are critical to testing hypotheses of dinosaur provinciality in Laramidia, including the existence of a distinctive polar fauna known as the Paanaqtat Province.

**Funding Sources** National Science Foundation EAR 1226730 and EAR 1736515

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

### THE CURSE OF THE MUMMY'S HAND: DIGIT CONSOLIDATION WITH MULTI-DIGIT NAIL PARTICIPATION REVEAL A NOVEL FORM OF SYNDACTYLY IN THE HAND OF A MUMMIFIED *EDMONTOSAURUS*

Drumheller, Stephanie K.[1], Boyd, Clint A.[2], Mayhall, Miles[1], Stalker, Emma[1], Householder, Mindy[3]

[1]Earth and Planetary Sciences, University of Tennessee, Knoxville, Tennessee, United States, [2]Fossil Resource Management Program, North Dakota Geological Survey, Bismarck, North Dakota, United States, [3]State Historical Society of North Dakota, Bismarck, North Dakota, United States

A trend towards digit consolidation in the manus within Ankylopollexia, eventually forming a unified "mitten" of soft tissue encasing multiple digits, has been inferred from trackway and rare soft tissue evidence. Detailed morphological descriptions of this unusual hand morphology have been hindered by ambiguous or poorly preserved soft tissues and a lack of identified osteological correlates. An exceptionally well-preserved specimen of *Edmontosaurus* (NDGS 2000) that includes a right manus with associated dermal tissues provides an unprecedented opportunity to explore the interplay of soft and bony tissues in this structure. Computed tomographic (CT) scanning was used to assess the morphology of the soft tissues and underlying bones. Instead of preserving more flexible, semipalmated webbing between the digits, which would allow independent movement of individual digits, this specimen exhibits a complex form of syndactyly, in which adjacent digits are more completely bound by soft tissues, restricting their mobility and forming a functionally unified structure. Digits III and IV are indistinguishably bound together by soft tissue, while digit II is also tightly connected via soft tissue from the proximal end through the base of the ungual, leaving only the nail of digit II independent. In contrast, a single, enlarged nail bridges the distal ends of digits III and IV. While adaptational syndactyly is known in a small number of extant taxa, and congenital conditions resulting in syndactyly are documented across much of Tetrapoda, nails are typically either retained in each individual digit (as in digit II) or lost completely. This fossil represents the first example of nail interaction across multiple digits, resulting in a highly stabilized, consolidated manus. This unique condition likely results from digit IV in basal ornithopods being reduced and likely lacking a nail prior to the evolution of this structure. By comparing the morphology of this specimen to existing trackway, skeletal, and rare soft tissue data, it becomes possible to better track the evolution of this novel style of syndactyly, from the fully separate digits in basal ornithopods, to the complete syndactyly between digits III and IV, with partial participation of digit II, present in hadrosauroids. By drawing from these multiple lines of evidence, a more wholistic interpretation of the evolution, development, and function of the hadrosaurian manus is possible.

**Funding Sources** This research was funded by the David B. Jones Foundation, the state of North Dakota, and the University of Tennessee Center for Student Success.

Technical Session 1: Sauropod & Ornithischian Dinosaurs (Wednesday, October 18, 2023, 8:00 AM)

**FINITE ELEMENT ANALYSIS HIGHLIGHTS CHANGES IN FEEDING MECHANICS IN A CRANIAL ONTOGENETIC SERIES OF *CORYTHOSAURUS CASUARIUS* (ORNITHOPODA: HADROSAURIDAE)**

Dudgeon, Thomas, Evans, David

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Lambeosaurines, a lineage of duck-billed herbivorous dinosaurs, exhibit extreme modifications to the facial skeleton, where the premaxillae, nasals, and prefrontals are modified to form their supracranial crests. The juveniles are crestless, and the crest developed through ontogeny. The crests are hypothesized to have facilitated intraspecific communication via sound production and sociosexual visual display. Oddly, these delicate crests are extensions of the premaxillae and nasals onto the skull roof, where stress from feeding is usually dissipated in amniotes. Here, we use finite element analysis (FEA) to investigate the stress distribution throughout the skull of an ontogenetic series of the lambeosaurine *Corythosaurus casuarius* during simulated feeding. This ontogenetic series may also provide insight into the evolution of feeding mechanics in hadrosaurids, from the plesiomorphic crestless state to the derived crested state. Two juveniles, a subadult, and an adult were CT scanned and segmented to generate 3D models of the skull and lower jaws for manipulation. The models were then retrodeformed to repair missing or damaged areas. Jaw muscles were reconstructed to calculate maximum muscle input forces, and restraints were placed on the anterior aspect of the premaxillae and jaw joints to simulate biting vegetation. The reconstructed models were then subjected to FEA to map the distribution of stress throughout the skulls during biting and chewing, with the bone and dental batteries modeled as separate materials. Results demonstrate a change in stress distribution through ontogeny. Crestless juveniles transfer stress posterodorsally, primarily through the lateral processes of the premaxillae, whereas the crested subadult and adult dissipate less stress through the premaxillae, instead concentrating it in the temporal region and facial skeleton. The pattern of stress observed here differs from that of other previously described dinosaur groups, where stress is dissipated posteriorly through the roof of the snout. These

results suggest that the expansion of the premaxillae and nasals over the skull roof to form the crest altered the distribution of stress in the lambeosaurine skull during feeding. This pattern in an adult lambeosaurine differs from previous work done on other ornithopods and suggests the potential for evolutionary trade-offs between feeding efficiency and the development of bizarre cranial structures in lambeosaurine evolution.

**Funding Sources** This research is funded by an Ontario Graduate Scholarship and NSERC Vanier Canada Graduate Scholarship to TD, and a NSERC Discovery Grant to DE (RGPIN-2018-06788).

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Preparators' Session (Thursday, October 19, 2023, 8:00 AM)

**FOSSILS IN FOCUS: ASSESSING THE POTENTIAL OF ACCELERATING DIGITAL PREPARATION WITH AI-ASSISTED SEGMENTATION ACROSS MULTIPLE FOSSIL TYPES**

Duffy, Franklin[1], Petermann, Holger[1], Lessner, Emily[1], Dougan, Lindsay G.[1], Lyson, Tyler[1], Chin, Karen[2]

[1]Earth Sciences, Denver Museum of Nature and Science, Denver, Colorado, United States, [2]Geological Sciences, University of Colorado Boulder, Boulder, Colorado, United States

Computed tomography (CT) scanning has revolutionized the study of vertebrate fossils, providing a non-destructive method to examine specimens through digital preparation and endocasting. However, generating accurate 3D models of fossil specimens from CT data remains a challenging and time-consuming task, especially for fossils that have not been mechanically prepared. Reducing the significant time commitment of studies that utilize scan data would tremendously increase the output of digital reconstructions and related research. Artificial intelligence (AI) is one potential tool that could be used to accomplish this. AI can learn from a small training dataset of segmentations created by an experienced technician or researcher and use the data to segment an entire scan. Here, we evaluate the ability of AI to segment CT data of fossils using scans of varying quality to identify optimal practices and novel applications of this approach across a wide range of fossil types. We trained regression models and convolutional neural networks (CNNs) created for clinical scan data to segment fossil and zoological specimens in various stages of preparation. We used Random Forest and U-Net model architectures because of their integration in the 3D visualization software, Dragonfly. Regression models were faster to train and more computationally efficient, while CNNs could recognize the more complex patterns in the CT data. Tissues of zoological specimens were easily separated using regression models, providing a baseline expectation for optimally segmented fossil data. Fossils show a range of success based on level of preparation and typically require using a CNN. Sutures of fully prepared fossils can be mapped, allowing for easier bone-by-bone segmentation. Compressed vertebrate fossils can be digitally separated from their matrix but require additional post-processing to separate adjacent elements. Remains encased in coprolites and concretions are challenging for AI and often require considerable manual corrections to create accurate 3D models; however, CNNs can locate elements in these specimens that might otherwise go unnoticed. Our study shows that AI can be highly effective in future efforts to digitally prepare a diverse array of vertebrate fossils. Future development of a neural network specifically designed for segmenting fossil CT data will strengthen the growing relevance of machine learning in paleontology and save researchers countless hours in the long run.

**Funding Sources** Denver Museum of Nature and Science, National Geographic Society, David B Jones Foundation, Lyda Hill Philanthropies

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Technical Session 1: Sauropod & Ornithischian Dinosaurs (Wednesday, October 18, 2023, 8:00 AM)

**ONTOGENETIC ANALYSIS OF A JUVENILE BRAINCASE OF *DRYOSAURUS ELDERAE* (DINOSAURIA: ORNITHOPODA) FROM THE UPPER JURASSIC MORRISON FORMATION OF UTAH: NEW PHYLOGENETIC IMPLICATIONS FROM COMPUTED TOMOGRAPHY**

Dunfee, Daniel R.[1], Ridgely, Ryan[2], Lamanna, Matthew[3], Witmer, Lawrence M.[2]

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Museum of Natural History, Pittsburgh, Pennsylvania, United States

Ongoing analysis of skulls of the early-diverging iguanodontian ornithopod dinosaur *Dryosaurus elderae* from the Upper Jurassic Morrison Formation of Dinosaur National Monument (Utah) using computed tomography (CT scanning) provides new insight into ontogenetic changes in the braincase, with potential implications for dryosaurid phylogeny. The three skulls referred to *D. elderae* differ in size and comprise an intraspecific growth series of three distinct ontogenetic stages: a juvenile (CM 11340), a subadult (CM 3392), and an isolated adult basicranium (CM 87688). The braincase of CM 11340 represents one of the ontogenetically youngest and most complete examples among non-hadrosauroid ornithopods, and prior analyses indicated clear signs of juvenility, such as its small size and proportionally large orbits, short face, and large neurocranium. Our studies confirm those findings, but CT scanning reveals new details of braincase and endocranial structure. Slice thicknesses were 25 µm for CM 11340 and CM 87688 and 300 µm for CM 3392. The CT data were analyzed using both automated and manual segmentation within Amira-Avizo. The resulting surface models of the preserved braincase elements of CM 11340 are of high fidelity and were exported to Maya for reassembly and restoration. Comparisons with ontogenetically older conspecifics (CM 3392, CM 87688) and a juvenile individual of the Tanzanian dryosaurid *Dysalotosaurus lettowvorbecki* revealed that, in CM 11340, the abducens canals and trigeminal foramina are not fully enclosed within the parabasisphenoid or prootic, respectively, whereas in CM 3392 and CM 87688 both structures are fully formed. A well-developed floccular recess was found in all three *D. elderae* specimens, suggesting that this species had relatively rapid visual reflexes that would benefit a small, unarmored animal. The surprising discovery of a theropod-like caudal tympanic recess in all three *D. elderae* specimens raises questions about the distribution of this feature in other ornithopods. Additional findings have phylogenetic implications for Dryosauridae, such as the ontogenetic exclusion of the supraoccipital from the foramen magnum. These new findings from the restored braincase of CM 11340 reveal additional intraspecific ontogenetic changes in cranial structure, support the separation of *D. elderae* from *Dryosaurus altus*, and enable the generation of a brain endocast for further analysis of ontogenetic changes in brain shape.

**Funding Sources** DRD—Ohio Univ. (OU) Honors Tutorial College. LMW & RCR—NSF IOB-0517257, IOS-1050154, IOS-1456503; SRC 2021-02973 & OU Heritage College of Osteopathic Medicine.

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Paleontological Management Poster Session (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

## THIS IS NO CAVE: PROACTIVE INVENTORY OF THE PLIO-PLEISTOCENE CAMP RICE FORMATION IN ORGAN MOUNTAINS-DESERT PEAKS NATIONAL MONUMENT, NEW MEXICO

Dunn, Colin R.[1], El Adli, Joseph J.[2]

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The Bureau of Land Management (BLM) Organ Mountains-Desert Peaks National Monument (OMDPNM) in southern New Mexico was designated in 2014 by Presidential Proclamation for its visual, cultural, geological, ecological, scientific, and paleontological resources. At that time, the most important Cenozoic fossils within OMPDNM were from cave deposits, most notably Shelter Cave and Aden Crater (latest Pleistocene–earliest Holocene). Beyond these cave deposits, no other scientifically important Pleistocene fossils were known from OMDPNM, despite containing exposures of the fluvial facies of the Camp Rice Formation, which are well-known for preserving late early Blancan–early Irvingtonian paleofauna. Most of the discoveries in the Camp Rice have occurred where the unit forms escarpments and low hills (e.g., La Union, Tonuco Mountain, Rincon Arroyo, and Hatch), but little effort has been made to survey the wide exposures southeast of Las Cruces, including within OMDPNM.

In 2019 and 2022, the BLM contracted proactive inventories focused on the fluvial facies of the Camp Rice Formation within the southernmost end of OMDPNM, straddling the northern portions of the North Franklin Mountains. These inventories utilized transects to provide a systematic study of the three field areas, capturing outcrops that conventional paleontological survey methods might miss. In total, the inventory areas occupied 9,703 acres of OMDPNM, and by the end of the two field seasons, approximately 3,140 acres had been directly surveyed by consultant field crews over a total of five weeks using seven paleontologists. Detailed stratigraphic sections were produced for each inventory area, which allowed for increased understanding of the local Camp Rice geology. A total of 124 fossil localities were discovered, yielding numerous bone fragments, plant remains, and insect burrows. Six specimens were determined to be scientifically important, including a canine phalanx, equid tooth and caudal vertebra, partial cervid dentary, distal camelid humerus, and proximal femur of *Arctodus* sp. The discovery of *Arctodus* within the Camp Rice Formation is notable as it dates that portion of the section to the Irvingtonian and is also only the second known occurrence of this taxon from the Formation. Future inventory is expected to produce more scientifically important specimens and will help correlate the Camp Rice Formation exposures within OMDPNM to those west of the Rio Grande River.

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Preparators' Session (Thursday, October 19, 2023, 8:00 AM)

**HYDROGEN PEROXIDE BREAKDOWN OF FOSSILIFEROUS SEDIMENTS FROM UPPER CRETACEOUS MICROVERTEBRATE SITES IN THE WILLIAMS FORK FORMATION, NORTHWESTERN COLORADO**

Dunn, Renee, Wurtz, Alyssa L., Heckert, Andrew B.

Geological and Environmental Sciences, Appalachian State University, Acworth, Georgia, United States

Vertebrate paleontologists identify the bulk of past diversity by collecting microvertebrate fossils. Screen washing is a technique commonly used by paleontologists to reveal microvertebrate fossils by some combination of soaking and sieving fossiliferous sediment. We collected sediment from two sites in the Upper Cretaceous (Edmontonian), Williams Fork Formation (WFF) in northwestern Colorado– Rebecca's Hollow (RH) and Super Charger Heaven (SCH). Rebecca's Hollow yields osteichthyans (bony fish), amphibians, turtles, crocodiles, dinosaurs, and mammals. We have found similar fossils such as crocodilian teeth and gar scales from SCH and expect to find many more due to its close proximity to RH.

Traditional screen washing processes of WFF sediments began with weighing ~600 grams of sediment, placing them into sieves, and soaking in gently agitated water for 24 hours. Afterwards, the sieves were taken out to dry and weighed again to calculate the amount of sediment lost. This method showed an average of 56% sediment breakdown at RH and 80% at SCH. Anecdotal reports suggest that the addition of 3% hydrogen peroxide ($H_2O_2$) improves sediment breakdown, apparently by assisting in breaking bonds between clay particles. Greater breakdown results in a higher concentration of fossils relative to sediment, improving picking efficiency. After verifying that $H_2O_2$ did not degrade fossils it was added to the screen washing process. Thus, we placed the sediment in a separate bucket filling it with 3% $H_2O_2$ until the sieves were completely submerged; letting them soak for 5-30 minutes. During this we observed off gassing as the clays were breaking down, until the sieves were relocated to the screen washing station to replicate the traditional process. This method showed an increased average breakdown of 87% for RH and 95% for SCH. This addition has reduced the concentrate for picking by ~70% making this a more efficient method of screen washing for the recovery of microvertebrate fossils. Hydrogen peroxide (3%) is not an especially hazardous chemical and our tests have not shown any visible damage to the microfossils. Re-washing previously screen washed concentrate from RH with $H_2O_2$ resulted in 47% additional breakdown, and fossils were immediately recovered from this concentrate that were not seen previously, supporting the importance of $H_2O_2$ in retrieving microfossils from fossiliferous sediment.

**Funding Sources** We acknowledge support from our Office of Student Research for funding.

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**A DESCRIPTION OF A NEW CHADRONIAN VERTEBRATE MICROSITE FROM THE WHITE RIVER GROUP OF NEBRASKA, U.S.A.**

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The White River Group contains an incredibly rich paleontological record spanning the late Eocene and early Oligocene epochs. Here we describe a new late Chadronian vertebrate microsite sampled from *Pogonomyrmex occidentalis* hills in Toadstool Geologic Park in Nebraska. This locality represents one of the last samples of White River biodiversity before the Eocene-Oligocene transition (EOT), which is characterized by significant high latitude cooling associated with the formation of ice caps in Antarctica. Data from this locality will provide a pre-EOT estimate of microvertebrate biodiversity and faunal composition that can be used to better understand the influence of the climate shift at the end of the Eocene.

We sampled 1468.4 grams of sieved material which yielded 32.9 grams of fossil material. From this fossil material we recovered 416 identifiable microvertebrate specimens and 228 identifiable plant specimens. The microvertebrate assemblage was dominated by mammals (258 identifiable teeth) and reptiles (56 identifiable elements, the majority of which are *Peltosaurus* scutes). As is typical of White River microvertebrate localities, the mammalian portion of the fauna (comprising 9 identified species) was primarily composed of rodents, lagomorphs, and eulipotyphlans (including *Eumys*, *Ischyromys*, *Paleolagus*, and *Micropternodus*). Among the plant remains we were only able to identify the genus *Celtis* with confidence, but a range of seed morphotypes were observed. Comparisons of this fauna with other spatially and temporally similar localities will provide context for the diversity observed here.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**EVOLUTION OF THE ARCHOSAURIAN SHOULDER MUSCULATURE**

Dupont, Caitlyn[1], Green, Anna C.[1], Hutchinson, John R.[2], Burch, Sara H.[1]

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The evolution of the shoulder musculature along the line to extant birds, particularly those changes related to the evolution of flight, has long been a topic of investigation. Previous studies have reconstructed the forelimb musculature of various nonavian theropod dinosaurs based on the myology of extant archosaurs, but the timing and sequence of the changes in these muscles have yet to be analyzed in a broad phylogenetic context. In this study, we investigated the anatomy of the musculature crossing the shoulder (glenohumeral) joint in a diverse array of archosaurs, turtles, and lepidosaurs to gather insights into the evolution of these muscles along the line to birds. The prior reconstruction of the myology of the early theropod *Tawa hallae* from the Late Triassic of New Mexico provided a basis for the identifying variation in the muscles of interest. We gathered data from published studies on muscle morphology, origin and insertion sites in birds, crocodylians, lepidosaurs, and turtles, which were used to formulate characters with discrete states to capture the variation present along this lineage. These characters were then coded in a phylogenetically broad sample of extant and extinct taxa, and ancestral states were reconstructed along the evolutionary lineage to birds using maximum likelihood to investigate the sequence of changes in the musculature. The pattern of myological evolution is complex, especially involving the transition to the modern avian shoulder architecture. Certain muscles, such as Trapezius and Triceps brachii, show a substantial amount of variation in extant taxa, which leads to uncertainty in their ancestral states. The identification of homologous attachment sites and osteological correlates for their attachment sites allows us to trace these changes in extinct archosauromorph taxa and better understand how the morphology of these muscles has evolved along this lineage.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**UNIQUE PRESERVATION AND REE ENRICHMENT OF FAMENNIAN FOSSILS FROM THE WATERLOO FARM DEPOSIT, SOUTH AFRICA**

During, Melanie A.[1], Goderis, Steven[2], Gess, Rob[3], Claeys, Philip[2], Ahlberg, Per[1]

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The Waterloo Farm deposit, a lagerstätte within the Witpoort Formation (Late Devonian, late Famennian) that outcrops near Grahamstown/Makhanda in South Africa, records a high-paleolatitude (approximately 70° S) estuarine ecosystem. It preserves a wide range of organisms such as charophytes, seaweeds, land plants, molluscs, arthropods, and a wide range of vertebrates including adult and juvenile fish as well as tetrapods. Soft tissue preservation is common, with remarkable examples like the oldest known lampreys. Despite being found within a diagenetically altered matrix that has undergone greenschist metamorphism, the fossils are morphologically well-preserved. To understand the geochemical composition of the fossils, multiple specimens including a trilete megaspore, a *Hyneria*-type fish scale, a *Hyneria* fin fragment, and a bivalve, were analyzed using micro-X-ray fluorescence. The results showed that the phosphates present in the Waterloo Farm fossils were enriched in REEs, which suggests that these elements may have played a role in the unique preservation of the fossils. It is possible that the mineralogically diverse sediment in the area, which underwent metamorphosis, may have contributed to the high levels of REEs found in the bone matrix. The discovery of this REE enrichment raises questions about the role of these elements in fossil preservation and their potential use as a marker for paleoenvironmental conditions. Further investigation is needed to fully understand the origin and significance of the REE enrichment in the Waterloo Farm fossils.

**Funding Sources** This research is supported by the Swedish Research Council (2020-03685).

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Paleontological Management Poster Session
(Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**CASE STUDIES IN THE MANAGEMENT OF FEDERAL PALEONTOLOGICAL COLLECTIONS AND RECOMMENDATIONS FOR THE FUTURE**

Eaton, Carrie[1], Breithaupt, Brent H.[2], Krishna, Janaki[3], MacKenzie, Kristen[4], Prassack, Kari[5], Rountrey, Adam N.[6], Santucci, Vincent[7], Schumacher, Bruce[8], Liggett, Gregory A.[9]

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Federal land management agencies, most notably the Bureau of Land Management, National Park Service, and the U.S. Forest Service, are responsible for protecting some of the United States' richest and most diverse paleontological localities. Federal paleontological resources, protected under the Paleontological Resources Preservation Act, span geologic time and include globally significant fossil localities preserving America's Paleontological Heritage. Federal agencies are ultimately responsible for these vast and diverse scientific collections, most of which are curated and made accessible in non-federal repositories (NFRs). These NFRs (e.g., universities; state, tribal, or local museums) serve as custodians and stewards for federal paleontology collections, and their staff are tasked with ensuring access and long-term preservation. The NFR managers work cooperatively with federal partners to curate specimens and share collection data, but the migration of digital data to federal collection management systems is especially challenging due their vast number, differences in how federal agencies manage their collections, and a lack of funding for collections work. Legacy collections of fossil material collected prior to the existence of computerized databases and a reduced number of paleontology staff positions in the federal government present additional limitations. The Society for the Preservation of Natural History Collection (SPNHC) Sessional Committee on U.S. Federal Collections has compiled a series of case studies, best practices, and recommendations for the care and management of federal collections. Through these cooperative efforts, this committee has identified ways in which the goals of federal and non-federal partners could be met more efficiently and effectively to the benefit of both parties. These are (1) harmonization of repository agreements across agencies, (2) establishment of regularly available federal funding and grants to support care for specimens collected from federal lands, and (3) increasing discoverability of federal specimens in online databases and data aggregators by standardizing metadata usage related to federal ownership status. These goals aim to enhance the management, preservation, and accessibility of paleontological resources from federal lands as well as improve the procedures surrounding their initial collection and use in scientific research, education, and outreach.

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**NEW PEDIOMYID METATHERIANS FROM THE PRINCE CREEK FORMATION – IMPLICATIONS FOR MAMMALIAN COLONIZATION IN THE LATE CRETACEOUS PALEO-ARCTIC, NORTHERN ALASKA**

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Late Cretaceous (late Campanian) strata of the Prince Creek Formation (PCF) in northern Alaska are best known for their endemic non-avian dinosaurian fauna, whereas fossil mammals have only recently been described. To date, the majority of mammalian fossils documented in the PCF are teeth and jaw fragments of the tiny pediomyid metatherian *Unnuakomys hutchisoni*. However, microvertebrate analyses at three localities have recovered rare teeth of two more pediomyids, tripling the known metatherian diversity of the PCF fauna. A M4 referred to *Iqualadelphis* sp. is similar in length to M4s of *U. hutchisoni*, but differs in its greater transverse width, narrower protocone, and absence of an ectoflexus and stylar cusps (save for stylar cusp A). *Iqualadelphis* is known from the Santonian and early Campanian of Montana and Alberta, so its presence in the PCF significantly expands the temporal and geographical range of the genus. Additionally, a new species of pediomyid is represented by an upper molar and several lower molars that are 15 – 25% larger than those of *U. hutchisoni*. The upper molar of this new pediomyid differs from those of *U. hutchisoni* in having a larger, more buccally-expanded metastylar lobe, deeper ectoflexus, presence of a tiny stylar cusp B, and anteroposteriorly-wider protocone. The lower molars are morphologically similar to *U. hutchisoni* but have relatively wider talonids. In the strict consensus tree, our phylogenetic analysis recovers *U. hutchisoni* and the two newly recognized PCF pediomyids in a trichotomy. However, in the majority rule tree, *U. hutchisoni* is sister to the new, somewhat larger pediomyid species, and *Iqualadelphis* is the successive sister taxon. Compared with contemporaneous 'Edmontonian' mammalian faunas from mid-latitudes of North America, the metatherian assemblage from the PCF exhibits high taxonomic selectivity in that only pediomyids are present. Notably, alphadontids are thus far absent from the PCF, but are diverse in mid-latitude North America during Late Cretaceous time. Our phylogenetic results suggest that there may have been a single colonization in the paleo-Arctic of Alaska by a pediomyid like *Iqualadelphis* during the Late Cretaceous, followed by endemic diversification resulting in *U. hutchisoni* and the new larger pediomyid. Our study, which suggests greater mammalian diversity in the PCF than previously recognized, is supported by parallel work on non-dental material.

**Funding Sources** National Science Foundation EAR 1226730 and EAR 1736515

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**GEOMETRIC MORPHOMETRICS OF MANDIBLES: A 3D MODEL FOR THE EVOLUTION OF MANDIBULAR TRAITS OF THE GEOMYOIDEA CLADE (ORDER: RODENTIA).**

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Geomyoidea, an ecologically diverse clade of rodents consisting of Geomyidae (gophers) and Heteromyidae (pocket mice, kangaroo rats, and their close relatives), have morphological adaptations that allow them to occupy a variety of extreme habitats across North and Central America. While the skull morphology of both families has been studied extensively, less work has focused on mandibular morphological variation and covariation in the context of the evolutionary history of the clade. Prior work has shown that in heteromyids, mandible shape can be utilized as a diagnostic tool to distinguish between species and even populations, although comparable analyses have not yet been done with geomyids. Mandibular shape may be related to aspects of climate and habitat (e.g., soil composition), and so may be a means to assess change in

environmental conditions over time. In this study, we performed 3D landmark-based geometric morphometric analyses on procrustes aligned coordinates of the mandibles of extant species of Geomyoidea to determine the major shape changes across the clade and within each family and examined the impact of allometry and phylogeny on mandible morphology. We performed principal component analyses (PCA) of the landmark coordinates for the clade as a whole, then again for each family separately. Results of the PCA for the whole clade reveal that the extant families occupy distinct areas of morphospace along the first two PCs. Eigenvector loadings along PC1 indicate the majority of variation occurring both laterally and dorso-ventrally in the coronoid and condylar processes and incisor alveolus. Similar shape changes occur along PC2, with the addition of dorsolateral changes in the angular process. Specimens of the same genera cluster together more on PC2 compared to PC1. Family-level PCAs reveal the mandibles of geomyids vary in fewer dimensions compared to heteromyids. In comparison to cranial variation across the same specimen dataset, geomyid mandibles vary more than their associated crania. Future work will involve increasing the sample size to be able to complete family and genus-level comparisons of mandible variation, comparing this variation to lower incisor procumbency, and layering phylogenetic and ecological factors to determine the main drivers in geomyoid mandible variation.

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**AN ENIGMATIC MARINE XENACANTH (CHONDRICHTHYES, ELASMOBRANCHII, XENACANTHIMORPHA) FROM THE LATE MISSISSIPPIAN (SERPUKHOVIAN) BANGOR LIMESTONE OF NORTHWEST ALABAMA, USA**

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Xenacanthimorpha is a group of elasmobranch chondrichthyans with a fossil record extending from the Early Carboniferous (Middle Mississippian, Viséan) to the Late Triassic. Xenacanths are generally characterized by dentition with well-developed lateral cusps with the median cusp greatly reduced in size or absent. Xenacanth taxa are found in fresh to brackish water deposits, with some being the apex predators of those environments. However, of interest here are xenacanths found in marine environments, which is considered to be the ancestral habitat for Xenacanthimorpha. Presently there are at least five taxa of Xenacanthimorpha that have been identified from marine sediments. *Bransonella* is a small bransonelliform xenacanth known from several species in exclusively marine sediments ranging from the Middle Mississippian to Middle Permian in age. From Xenacanthiformes, members of the family Diplodoselachidae, *Diplodoselache* (Middle Mississippian), *Dicentrodus* (Middle to Late Mississippian), *Hokomata* (Early Pennsylvanian), and *Reginaselache* (Middle Mississippian), are known from marine and lagoonal deposits. The indeterminate marine xenacanth *Hagenoselache* (Early Pennsylvanian) is considered. Here we present a new record of a xenacanthimorph from the Late Mississippian (Serpukhovian) Bangor Limestone from northwest Alabama, USA.

The Bangor xenacanthimorph is represented by an isolated tooth approximately 2 mm wide at the base. The tooth bears two relatively mesiodistally wide lateral cusps that are ornamented with branching V-shaped cristae, which extend about halfway up from the crown and are not connected. The outer margins of the cusps are relatively straight, while the inner margins are curved. The median cusp is absent. Much of the labial face below the lateral cusps is smooth. The shape of the lateral cusps is similar to those of xenacanthiform taxa such as *Orthacanthus* but the crown ornamentation on the labial surfaces of the lateral cusps is closer to those in *Bransonella*. The tooth base is ovate, and though worn, the basolabial projection is relatively wide. The overall tooth morphology suggests the Bangor xenacanthimorph is a new taxon. However, as this xenacanth shares a number of traits with both Bransonelliformes and Xenacanthiformes, it is presently difficult to place this taxon into either order until more specimens have been found and diagnosed.

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**LEGASEA: AI IMAGE RECOGNITION AND CITIZEN SCIENCE HELP CONTEXTUALIZE EX SITU QUATERNARY FOSSILS FROM THE DUTCH NORTH SEA**

Eijkelboom, Isaak, Schulp, Anne S., Hogeweg, Laurens, den Ouden, Natasja, Wesselingh, Frank

Naturalis Biodiversity Center, Utrecht, Netherlands

The Dutch North Sea is a treasure trove for paleontologists and archeologists. Over the past 70 years, hundreds of thousands of late Quaternary vertebrate fossils and artefacts have been collected from fishing nets and from sand nourished beaches by fossil enthusiasts. The lack of specific legislation on paleontological heritage in the Netherlands results in large contributions to science by citizen scientists. Much of the ongoing research builds upon material recognized and recovered by amateur fossil collectors. This intensive collaboration makes the quality and quantity of the Dutch ice age fossil record unique in the world.

Because these fossils are found ex-situ, it is challenging to identify faunal assemblages and link them to the depositional environment from which they originate. The LegaSea project aims to identify and characterize late Quaternary vertebrate communities from the rich beach finds through a novel AI-assisted citizen science approach.

The combined use of citizen science and AI such as deep learning algorithms and computer vision has seen a tremendous development over the last few years due to increasing accessibility of high-performance computing power and the smartphone revolution. For example, biodiversity monitoring has seen numerous projects where citizen scientists collect data with their phone or annotate pictures from camera traps. Refinements of algorithms, along with strategies such as transfer learning and data augmentation make it possible to apply AI to datasets of relatively rare and often fragmented objects such as vertebrate fossils.

In the LegaSea project we incorporate photos from both museum collections and the citizen science web portal oervondstchecker.nl to create a large dataset that covers late Pleistocene-Holocene mammal faunas. This dataset is used to train and test a machine learning algorithm that groups these fossils in faunal assemblages based on species and taphonomy. Representative fossils from these assemblages are then dated in order to link the assemblages to the independently dated stratigraphy from which the fossils originate. This way the depositional environment and the biota are linked. The contextualized fossils will help us better understand changes in biodiversity during the late Quaternary of northwestern Europe as a result of climate change and human activity.

**Funding Sources** This project is funded by the Dutch government agency NWO through an "Open Competitie ENW-M" grant (dossier number: OCENW.M20.360).

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Virtual Posters

**X-RAY MICROTOMOGRAPHY AND 3D VISUALIZATION OF A PLESIOSAUR PROPODIAL (REPTILIA: SAUROPTERYGIA) FROM THE LATE CRETACEOUS OF SOUTHERN SWEDEN PROVIDES INSIGHTS IN BONE HISTOLOGY, BONE MICROSTRUCTURES, AND BONE GROWTH.**

Einarsson, Elisabeth[1], Gren, Johan A.[2], Johansson, Sara[2]

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Polycotylid and elasmosaurid plesiosaurs inhabited the Kristianstad Basin during Late Cretaceous (uppermost lower Campanian *Belemnellocamax mammillatus* zone) around 80 million years ago. The setting represents one of the most famous Mesozoic fossil sites in Scandinavia. The Kristianstad Basin fossils are generally fragmentary and isolated due to high-energy environments in a protected shallow inner shelf bay with limited mixing from other water bodies.

This study includes an isolated plesiosaurian propodial (R2008) from Ivö Klack, currently housed in the Natural History Museum of Stockholm. As preserved, the propodial measures 109 mm in length, 38 mm in width at the proximal shaft and 68 mm in the distal expanded part. A foramen is visible on the posterior surface of the shaft.

We used X-ray microtomography to investigate inner bone structure and bone histology of the specimen. The method is non-destructive and provides a prime alternative to conventional thin sections. In addition to visualization through arbitrary 2D slicing of the 3D volume, image analysis was used to digitally segment hollow vascular canals. The internal vascular network and the foramen of the external surface were then visualized in 3D.

Virtual longitudinal sections of R2008 display cancellous bone in a fan-like shape, emerging from the medullary cavity at the center of the specimen. The cancellous bone is surrounded by denser compact bone, in turn displaying a series of at least 10 lines of arrested growth (LAGs).

Vascular canals are traceable throughout the cancellous bone, with a few large vessels at the center, branching into a multitude of smaller vessels at both the proximal and distal ends of the propodial. Our 3D model of the vascular canals provides a detailed overview of the nutrient distribution network, giving insight into the pattern of bone growth.

We found that the method is valuable for highlighting features such as LAGs in compact bone, the contacts between compact and cancellous bone, and the network of vascular canals, while avoiding destructive sectioning of the sample. Use of this methodology is recommended as an alternative for exploring bone histology of fossil specimens where the integrity of the sample needs to be preserved.

**Funding Sources** The 4D Imaging Lab, Lund University provided access to the X-ray tomograph (RX Solutions). Natural History Museum in Stockholm provided access to the specimen (R2008).

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

## ACTINOPTERYGIAN FISH ASSEMBLAGE FROM THE UPPER CRETACEOUS (CAMPANIAN-MAASTRICHTIAN) DUWI FORMATION, WESTERN DESERT, EGYPT

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Late Cretaceous (Campanian-Maastrichtian) marine actinopterygians from the southern Tethys platform are underreported and understudied in comparison to chondrichthyans from this region. Exposures of the Duwi Formation near the Dakhla, Kharga and Baris oases preserve a diverse assortment of actinopterygian fishes not previously reported from this unit. Horizons yielding fossils represent shallow marine deposits of upper Campanian-lower Maastrichtian age. The actinopterygian assemblage includes representatives of several groups of large-bodied, predatory fishes, all of which belong to the teleost total group: †Pachycormiformes (†Pachycormidae), †Pachyrhizodontiformes (†Pachyrhizodontidae), †Ichthyodectiformes (†Saurodontidae), and Aulopiformes (†Enchodontidae, † Dercetidae and †Cimolichthyidae). The presence of saurodontids in the Duwi Formation is noteworthy as the first confidently identified fossils for this group from Africa. Specimens are based on and diagnosed from isolated and fragmentary elements, implying significant disarticulation prior to burial. Palaeobiogeographically, actinopterygians of the Duwi Formation show compositional similarity with assemblages from the Northern Tethys Platform and the Western Interior Seaway of North America, consistent with mounting evidence for communication across the Tethys Ocean. Additional exploration of the uppermost Cretaceous units in southern Egypt promises potential for the discovery of important fossils to better characterize the composition and paleogeographic distribution of the latest Cretaceous ichthyofauna of the Tethys region.

**Funding Sources** Mansoura University, American University in Cairo, Science and Technology Development Fund (STDF) and National Geographic Society/Waitt Foundation (W88-10).

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Technical Session 5: Ungulates (Wednesday, October 18, 2023, 1:45 PM)

## NO SUPPORT FOR AN INTERCHANGE-DRIVEN EXTINCTION OF NOTOUNGULATES AND LITOPTERNS BASED ON DIVERSIFICATION RATES OF SOUTH AMERICAN NATIVE UNGULATES (SANUS)

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South American native ungulates (SANUs) comprise a highly diverse, possibly monophyletic assemblage of mammals, with five currently recognized orders (Notoungulata, Litopterna, Astrapotheria, Pyrotheria, and Xenungulata). This group has a long (~65 Ma) evolutionary history but went extinct relatively recently, with the last species surviving until ~12 ka. The decline and extinction of SANUs has often been attributed to competition from Holarctic ungulates during the Great American Biotic Interchange (GABI), but this hypothesis has never been tested quantitatively. Here, we use lineage-through-time analyses of a new dated supertree phylogeny including more than 300 SANU species to track diversification patterns of this group throughout the Cenozoic. We identify three major events in SANU evolutionary history: (1) an "explosive" diversification in the early Eocene (60–50 Ma); (2) a major turnover at the Eocene–Oligocene boundary (~35 Ma); and (3) a protracted decline beginning in the late middle/early late Miocene (12–10 Ma) and persisting until the extinction of the group. The decline of SANUs significantly predates the earliest stages of the GABI and is seemingly unaffected by the large-scale immigration of northern ungulates circa 3.5 Ma. Instead, the decline of SANUs seems to coincide with the diversification of large, folivorous caviomorph rodents (Cavioidea and Chinchilloidea) and xenarthrans (Pilosa and Glyptodontoidea) during the late middle to early late Miocene. This pattern resembles the turnover between browsing and grazing ungulates on northern continents associated with the expansion of $C_4$ grasslands during the same timeframe, albeit with hypselodont SANU lineages like notoungulates in the role of browsers (agreeing with previous suggestions these animals were not grazing specialists). This suggests the expansion of open habitats may have been an abiotic driver of passive replacement between ungulate and non-ungulate herbivores in late Cenozoic South America. This turnover in the herbivore guild coincides with similar turnovers in the South American metatherian fauna (e.g., the decline of paucituberculatans/sparassodonts and the radiation of didelphids), suggesting a possible large-scale faunal turnover in South American terrestrial ecosystems 12–10 Ma.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**THE EVOLUTION OF THE PINNIPED (MAMMALIA, CARNIVORA, PINNIPEDIA) BACKBONE**

Esteban, Juan Miguel, Martin-Serra, Alberto, Perez Ramos, Alejandro, Pérez-Claros, Juan A., Figueirido, Borja

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Here, we explore vertebral disparity, morphological integration and its relationship with locomotor adaptations in the presacral vertebrae of a set of living and extinct pinnipeds (Carnivora, Pinnipedia). The results obtained show that vertebral morphological disparity is higher in phocids than in otariids. In addition, disparity through time analyses indicate that, for most vertebrae, otariid subclades tend to explore different regions of the morphospace, whereas phocid lineages overlap within similar regions. Finally, the study of integration between vertebrae in otariids reveals an absence of a modular pattern along the spine, in contrast to a slightly modular pattern found in phocids. These results suggest that adaptation to the aquatic environment in both groups follows two completely different pathways, probably associated with their mode of aquatic locomotion. Moreover, functional analyses based on joint mobility indicate a significant association between the patterns of disparity and integration and locomotor performance in the pinniped vertebral column.

**Funding Sources** Spanish Ministry of Science and Universities (PID2019-111185GB-I00).

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**A GIGANTIC HADROSAURID SPECIMEN FROM THE UPPERMOST CRETACEOUS HELL CREEK FORMATION OF MONTANA WITH IMPLICATIONS FOR DINOSAUR DIVERSITY**

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Hadrosaurids were Late Cretaceous herbivorous dinosaurs known for their complex dental batteries, duck-like rostral area, and impressive cranial crests. *Edmontosaurus annectens* is currently the only known hadrosaurid in the uppermost Cretaceous Hell Creek Formation (HCF) of Montana and surrounding regions. *E. annectens* is among the largest known hadrosaurids, with a maximum recorded skull length of ~ 128 cm. In 2004, a field crew from Museum of the Rockies (MOR) unearthed a gigantic partial hadrosaurid skull (MOR 1609). Fossils collected included a maxilla, jugal, partial pterygoids, and a partial ectopterygoid. The size of the preserved elements (maxilla length 65.7 cm) suggests a total skull length of ~ 177 cm. MOR 1609 was originally regarded as a gigantic specimen of *Edmontosaurus annectens*, but analysis of its morphology highlights several peculiarities. The jugal of MOR 1609 displays a shallow and short concavity between the ventral and quadratojugal flanges and the postorbital process divides the orbit and infratemporal fenestra evenly. In *Edmontosaurus*, the jugal typically displays a very pronounced concavity and subequal orbit and infratemporal fenestra. The maxilla of MOR 1609 exhibits non-continuous foramina between the anterior process of the jugal and the ventral margin of the jugal process. Typically, these foramina are continuous in *Edmontosaurus*. The maxilla and jugal morphologies observed in MOR 1609 are more similar to those observed in the saurolophin hadrosaurid *Saurolophus*. Incorporation of MOR 1609 into a phylogenetic analysis resulted in a polytomy for the strict consensus tree; the 50% majority rule tree places MOR 1609 outside of Edmontosaurini and within Saurolophini. Given the large size of the specimen, it is possible that the cranial features noted here represent late-stage ontogenetic changes within *Edmontosaurus*. Alternatively, this suggests the presence of a second hadrosaurid taxon in the HCF, impacting the current view of dinosaur diversity trends just prior to the K/Pg extinction event.

**Funding Sources** 2004 Hell Creek Project funding by Intellectual Ventures

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**THE GROWTH AND FORM OF HORNS IN MAMMALS AND DINOSAURS**

Evans, Alistair R., Edwards, Jonathan

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Horns are a particularly striking feature of many mammals and dinosaurs. Their importance in defense and offense make them a valuable system for investigating behavior and social interactions in past ecosystems, but our knowledge of the growth and form of horns is deficient. Mammal horns are constructed from two components – an underlying bone core, and an external keratinous sheath – and dinosaurs likely had a similar structure. However, the sheath rarely fossilizes, and so our conception of the appearance and function of horns in extinct animals is incomplete. Here we analyze the shape of horns using the growth pattern called the power cascade, which uses a power law to model the expansion of the radius of a structure with its length. We analyzed horn shape of over 50 species of bovid mammals from CT scans, measuring the shapes of the core and sheath separately. Both cores and sheaths were generally well-described by the power cascade, allowing us to place them in a combined morphospace of power cascade Slope and Aspect Ratio. By correlating the shapes of the cores and sheaths, we can infer the likely shape of the sheath from the shape of the core. We have applied this method to the ceratopsid *Triceratops* to estimate the likely length and 3D shape of any sheath that may have been present on its postorbital horns.

**Funding Sources** Australian Research Council Discovery Project DP180101797

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**A COMPREHENSIVE PHYLOGENY OF PINNIPEDIMORPHA REVEALS AN ALTERNATIVE HYPOTHESIS OF CROWN PINNIPED RELATONSHIPS**

Everett, Christopher J.

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*Pinnarctidion iverseni* and other unnamed taxa recently discovered from the early Miocene of the Pacific Northwest reveal the considerable morphological disparity among early pinnipedimorphs and provide additional context for phylogenetic interpretations. A comprehensive phylogenetic analysis of fossil pinnipedimorphs using over 100 craniodental characters recovers Odobenidae as the most basal crown pinniped. This finding contradicts previous hypotheses that the walrus clade is sister to either Phocidae or Otariidae. The earliest fossil taxa referred to Odobenidae, such as *Proneotherium repenningi* and *Prototaria primigena*, display plesiomorphic features that suggest they may have diverged prior to the crown group. Whether or not these interpretations are correct, such a broad sample of early pinnipedimorphs provides necessary context for reconstructing the sequence of character transitions that occurred prior to the origin of Pinnipedia.

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Technical Session 3: Fishes & Amphibians (Wednesday, October 18, 2023, 8:00 AM)

**ANURAN TAPHONOMY AS FOUNDATION FOR A NEW TAPHONOMIC MODEL FOR THE EOCENE GEISELTAL KONSERVAT-LAGERSTÄTTE (GERMANY)**

Falk, Daniel[1], Wings, Oliver[2], McNamara, Maria E.[1]

[1]School of Biological, Earth and Environmental Sciences, University College Cork, Cork, Co. Cork, Ireland, [2]Natural History Museum Bamberg, Bamberg, Bavaria, Germany

The Geiseltal Konservat-Lagerstätte (Eocene, Germany) is represented by ca. 25,000 fossil vertebrate remains that were recovered from open lignite mines in central Germany in the early 20$^{th}$ century. The taphonomy of the biota, including the preservation of soft tissues is poorly understood. Early studies of the vertebrates reported remarkable (sub)cellular details of muscle, cartilage, blood vessels, feathers, hair, reptile scales, and bacteria, preserved as three-dimensional silica replacements. This mode of preservation is unknown from other vertebrate Konservat-Lagerstätten and the claims of cellular fidelity lack verification by modern techniques. We examined soft tissues of the anurans using electron microscopy, electron probe microanalysis, Fourier-transform infrared spectroscopy, Raman spectroscopy, and synchrotron rapid scanning-X-ray fluorescence analysis. Our results reveal that soft tissues are not preserved as silica replacements, but as layers of skin and melanosomes. The skin is preserved in calcium phosphate and comprises only the anuran-specific Eberth-Katschenko layer of the mid-dermis. The melanosomes are carbonaceous with a sulfur component and exhibit tissue-specific geometries. These soft tissue features – phosphatized skin and carbonaceous melanosome films – recur in vertebrates from other Konservat-Lagerstätten (e.g., the Miocene Libros biota), and are the foundation for a taphonomic model based on phosphatization and sulfurization. Recognition of this taphonomic model will inform on the taphonomic pathways available for preservation of vertebrate soft tissues in the fossil record.

**Funding Sources** This research is funded by an Irish Research Council Government of Ireland Postgraduate Scholarship (GOIPG/2018/3354).

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**A NEW NEARLY COMPLETE EARLY SQUAMATE FROM THE UPPER JURASSIC, MORRISON FORMATION**

Fenstermaker, Catherine M., Meyer, Dalton, Morris, Zachary S.

Earth and Planetary Science, Yale University, New Haven, Connecticut, United States

Our understanding of the initial diversification of squamates and acquisition of clade-specific features has been hampered by the limited number of Mesozoic specimens and their generally fragmentary nature. Here we describe a new specimen, UMNH.VP. 13829 (A & B) from the Morrison Formation, which is the most complete known Jurassic squamate from North America. The specimen is preserved in a fine-grained siltstone that comes from Upper Jurassic sedimentary sequences and it contains a part and counterpart component, each showing a near-complete skeleton. Micro-CT scanning has revealed incredibly detailed gross anatomy, including a complete flattened skull, some remnants of the rib cage, and the vertebral column. Although the pectoral girdle and anterior vertebral column are poorly preserved, all four limbs are well-preserved with the wrist, ankle, elbow, and knee joints found in articulation. The hands and feet are mostly complete as well, with multiple digits represented. The pelvic girdle and posterior vertebral column are well preserved in UMNH.VP. 13829, revealing conspicuous procoelous vertebrae. Based on this and other anatomical characters, we can positively determine that UMNH.VP. 13829 is an early squamate. The block also contains a wealth of clearly archosaurian elements that are distinct in the matrix. These include a metatarsal from an indeterminate archosaur and the proximal end of a humerus from what appears to be a juvenile pterosaur. We will synchrotron scan this specimen this summer to obtain greater clarity and further evaluate the disarticulated elements present. Further work will involve a complete anatomical description and inclusion of this specimen in a phylogenetic analysis to test our synapomorphy based assessment. However, this specimen marks a new oldest age for a squamate fossil of this completeness and provides important information about the initial radiation of squamates in North America.

**Funding Sources** This project received funding from the Yale Institute for Biospheric Studies Early Grant and Zachary Morris was funded by NSF-EAR-PF-1952888.

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Technical Session 7: Birds (Thursday, October 19, 2023, 8:00 AM)

### TWO SPECIAL LUMPS OF STONE: INSIGHTS INTO MODERN BIRD ORIGINS FROM THE TYPE MAASTRICHTIAN

Field, Daniel J.[1], Benito, Juan[1], Chen, Albert[1], Kuo, Pei-Chen[1], Widrig, Klara E.[1], Ksepka, Daniel T.[2], Jagt, John[3]

[1]University of Cambridge, Cambridge, Cambridgeshire, United Kingdom, [2]Bruce Museum, Greenwich, Connecticut, United States, [3]Natuurhistorisch Museum Maastricht, Maastricht, Netherlands

Only a handful of phylogenetically controversial fossils have yet been put forward that cast light on the early morphology of crown birds (Neornithes), precluding robust assessment of the nature of the last common ancestor of arguably the world's most conspicuous clade of terrestrial vertebrates, represented by nearly 11,000 extant species. However, two remarkable fossils deriving from the Type Maastrichtian of Belgium (~66.7 million years ago) have recently illuminated important aspects of cranial and postcranial morphology early in crown bird evolutionary history. Together, *Asteriornis maastrichtensis* (among the world's oldest-known crown birds) and *Janavis finalidens* (a crownward stem bird) represent the first documented example of co-occurring crown birds and non-neornithine avialans, and the excellent three-dimensional preservation of both specimens enables long-sought inferences into the origins of key avian morphological features. For instance, both the discrete morphology and three-dimensional geometry of the skull of *Asteriornis* reveal a remarkable degree of evolutionary stasis in the cranial morphology of galloanseran birds, and *Janavis* illustrates both that the ancestral crown bird was neognathous—not palaeognathous, as long assumed—and exhibits an extraordinary degree of vertebral pneumaticity, exceeding that of virtually all known stem birds. Although important aspects of crown bird origins remain shrouded in mystery, these late Maastrichtian fossils reveal that some of the longest-standing assumptions about crown bird origins may need to be reconsidered.

**Funding Sources** UKRI grant MR/S032177/1

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Technical Session 13: Fishes - Actinopterygians (Friday, October 20, 2023, 1:45 PM)

### INTEGRATING FOSSIL AND EXTANT DATA IN ORDER TO UNDERSTAND PATTERNS OF RAY-FINNED FISH BRAIN EVOLUTION

Figueroa, Rodrigo T., Friedman, Matt

Department of Earth and Environmental Sciences, University of Michigan, Ann Arbor, Michigan, United States

Ray-finned fishes exhibit remarkable morphological diversity and include roughly half of living vertebrate species. Nevertheless, understanding their neuroanatomy and brain evolution is limited since detailed neuroanatomical studies have focused on only a handful of taxa. Studies on ray-finned fish brains show important innovations unique to the group (e.g., everted telencephalon, torus semicircularis). However, the evolutionary origins, timing and ordering of these and other innovations is still poorly understood because early-diverging crown lineages are highly apomorphic. Fossil

evidence from a Carboniferous ray-finned fish demonstrated that an everted telencephalon is not a character of the whole group and indicated that stem ray-finned fishes might have exhibited a mosaic of characteristics found in extant lineages. These findings demonstrate the need to integrate paleontological and neontological evidence for understanding actinopterygian brain evolution. Here I present new evidence from fossilized soft tissues and integrate it with iodine-stained micro-computed tomography (dice-CT) data for living species. Taken together, these indicate the sequence of origin of key traits, provide a timeline for these changes, and establish how rates of brain evolution might have changed through time and between brain regions in the crown group. Results indicate that an everted telencephalon originated no later than the latest part of the Carboniferous to the early Permian, but other ordering of other important ray-finned fish brain features remains unclear given current fossil evidence. Data on extant species indicates shifts in morphospace occupation between three major divisions of ray-finned fish diversity (non-teleosts, non-acanthomorphs, and acanthomorphs), but with considerable overlap between the acanthomorph and non-acanthomorph teleosts. Additionally, living ray-finned fishes exhibit a much higher diversity of endocast shape than previously expected—comparable to that of brain shape—despite the low encephalization coefficient (brain volume/endocast volume) of most taxa. Ray-finned fish brain evolution is not only complex in terms of bearing numerous anatomical innovations, but also bears strong phylogenetic signal in brain-shape evolution that might limit inferences of ecology from brain morphology.

**Funding Sources** Department of Earth and Environmental Sciences, University of Michigan; Society of Systematic Biologists Graduate Student Research Award

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**BECOMING GIANT: THE EVOLUTION OF BODY SIZE IN UINTATHERES**

Flora, Geoffrey W.

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Following the extinction of the non-avian dinosaurs and the reorganization of ecological communities at the Cretaceous/Paleogene boundary, terrestrial mammals began to rapidly diversify both morphologically and ecologically. Additionally, terrestrial mammals expanded in body size by four orders of magnitude. The first order of mammals to achieve a truly large body size (greater than 1000 kg) were the Dinocerata (uintatheres). With near simultaneous fossil origins in North America and Asia during the Late Paleocene (56 Ma), the order expanded in mass from a small tapir (200 kg) to a large rhinoceros (2500 kg) by the Middle Eocene (45 Ma). This study investigates 8 uintathere species with complete, or near complete skull material, analyzing patterns of body size evolution within Dinocerata during their roughly 12-million-year history. Four abiotic factors including: delta-O-18, estimated land area, atmospheric oxygen percentage, and reconstructed mean annual temperature, all suggested to impact body size evolution on mammals above the order level. Results of the study suggests available land area and cooling climates correlates ($p<0.05$) with larger body sizes in uintatheres. This compares favorably with results from mammals above the order level. Interestingly, expansion of body size is non-linear across the evolutionary history of uintatheres. The earlier uintatheres (Prodinoceratidae) increased in body size very little during the first 3 million years of their evolution. They then double in body size following the Paleocene/Eocene Thermal Maximum, with the later uintatheres (Uintatheriidae) steadily increasing towards their maximum body size during the cooling environments of the Bridgerian. This analysis suggests the most significant event in the evolution of uintatheres was the loss of the upper incisors and the evolution of an artiodactyl-like horny pad at the front of the mouth during the Early Eocene Climatic Optimum (50 Ma). This event coincided with a diet shift from omnivory to obligate browsing in uintatheres and triggered a 5-times increase in body size, leading to the first truly large terrestrial mammals.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**2D MORPHOMETRIC ANALYSIS OF THE FIRST MOLAR OF MUROID RODENTS**

Flores, Deanna, Hopkins, Samantha

Earth Sciences, University of Oregon, Eugene, Oregon, United States

Rodents are the most diverse groups of mammals both in taxon richness and in morphological diversity, enabled in part by dental adaptations that facilitate diverse diets and ecology. The majority of the fossil record of rodents is isolated teeth, which can present challenges for taxonomic identifications. The Muroidea are commonly identified by the occlusal morphology of the first molar. However, these identifications are more difficult because dental morphology changes with wear. Past studies have used geometric morphometrics on occlusal outlines to identify teeth in a way that is not affected by wear. We have applied this method to the widespread North American Miocene cricetid *Copemys* to determine whether this method effectively discriminates species in this morphologically cryptic genus. *Copemys* and the related Oligocene *Leidymys* are ecologically and biogeographically important, yet their morphological limits and variation are not fully understood. Using photographs of specimens from several species, we digitized tooth outlines using 64 equally spaced semilandmarks. These coordinates were analyzed with Elliptical Fourier analysis, which describes the shape as a sum of harmonics of decreasing wavelength, yielding four Fourier Coefficients for each harmonic. Principal component analysis of the Fourier Coefficients of the first eight harmonics shows that the first five principal components encompass ~90% of the variation found in the outlines, particularly in the width of the tooth and the distal shape. Linear discriminant analysis using the first five principal components shows approximately 50% were identified correctly. Adding centroid size increased the percent identified correctly to 60%. Within-species variation is substantial, particularly in *Copemys pagei*. However, increasing the sample size may improve the capacity of the analysis to discriminate species accurately. The shape outline analysis of the first molar offers promise as a way to discriminate *Copemys* species that are minimally affected by tooth wear.

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Technical Session 15: Paleoecology & Paleoclimatology (Friday, October 20, 2023, 1:45 PM)

### ECOLOGICAL RECOVERY AND DIVERSIFICATION OF EARLY MESOZOIC, LOW LATITUDE VERTEBRATE ASSEMBLAGES

Foffa, Davide[1], Nesbitt, Sterling J.[1], Stocker, Michelle R.[1], Kligman, Ben T.[1], Marsh, Adam D.[2], Parker, William G.[2], Butler, Richard[3]

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Patterns of recovery and diversification following the Permian-Triassic Mass Extinction are unclear because of geographic and stratigraphic gaps in the fossil record, especially at low latitudes in Pangea. Here, we address this by chronicling the early Mesozoic terrestrial vertebrate record from the western United States. First, we critically reviewed the oldest vertebrate faunas, those from the Moenkopi Formation (Middle Triassic), using newly collected fossils from Arizona (Holbrook Member) and its lateral equivalent in New Mexico (Anton Chico Member). Our survey confirms a widespread and low-diversity (relative to younger assemblages) fauna in the Anisian. To understand how taxonomic diversity translates into ecological diversity, we developed and applied a new trait-based approach to the terrestrial vertebrate record of the U.S.A from the Middle Triassic (Anisian) to Late Triassic (Norian). We compiled occurrence lists from fossil assemblages of Arizona, New Mexico, Texas, Wyoming, and the East Coast. Our new sampling method integrates 'dark data' that are routinely left out of traditional paleoecological studies (e.g., indeterminate/fragmentary specimens, microfossils, and ichnotaxa) with new data drawn from fieldwork, literature, and museum collections. Each taxon was coded for five functional traits in a matrix designed to capture key aspects of their biology (i.e., diet, motility, habitat, growth, body size). Using a multivariate approach drawn from modern ecology we quantified the properties of the 'ecospace' occupied by each assemblage (i.e., ecological richness, disparity, redundancy) and their variation through time. Results show consistent levels of disparity and redundancy (=stability) across the sampled interval. Conversely, taxonomic and ecological richness are low in the Anisian, increase through the Carnian, and peak in the early Norian. All patterns are maintained when small-bodied taxa (<5kg) are removed to test the influence of microsites. We detected low functional turnover due to the stability of some ecological roles through time: specifically large-bodied aquatic (i.e., temnospondyl amphibians) and terrestrial (i.e., pseudosuchians) carnivores, and small-bodied herbivores. The diversification of pseudosuchians (e.g., aetosaurs, phytosaurs), and avemetatarsalians (i.e., pterosauromorphs, dinosauromorphs) into unoccupied ecological modes was largely responsible for increases in ecological diversity occurring through this interval.

**Funding Sources** Marie Sklodowska-Curie Actions: Individual (Global) Fellowship (H2020-MSCA-IF-2020; No.101022550) to D.F.

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Technical Session 21: Squamates (Saturday, October 21, 2023, 1:45 PM)

**USING MACHINE LEARNING AND PHYLOGENETIC COMPARATIVE METHODS FOR PREDICTION OF ECOLOGY IN FOSSIL TAXA FROM INNER EAR BONY LABYRINTHS OF TOXICOFERANS (SQUAMATA, REPTILIA)**

Forcellati, Meghan R.[1], Napoli, James G.[2], Zietlow, Amelia R.[3], Meyer, Dalton[4], Hanson, Michael[5], Watanabe, Akinobu[6], Raxworthy, Christopher[7]

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Historically, scientists hypothesized that inner ear shape is related to ecological mode and ancestry in reptiles. Recent studies sampling diapsid inner ear diversity have demonstrated this structure is correlated with a variety of phylogenetic, ecological, and physiological parameters. Investigations on this structure in lepidosaurs have focused on reconstructing the ancestral state of snake ecology. However, this research has not extensively sampled the Toxicofera, a hypothesized clade of lizards that includes Serpentes, Iguania and Anguimorpha. Determining how various factors influence inner ear morphology is essential for resolving the controversy surrounding the squamate phylogeny and for paleoecological reconstructions. By greatly extending the sampling of inner ear morphology in proposed sister groups to snakes, this allows us to make more general and robust interpretations of trends in this structure's shape. We apply both geometric morphometric (N=111) and conventional morphometric (N=97) sampling techniques to micro-computed tomographic scans of extant and fossil squamate inner ears to better understand how ecological, phylogenetic, and allometric variables are associated with the toxicoferan inner ear morphology. We then use machine learning methods to determine whether fossorial habits can be predicted using inner ear morphology. Finally, we use phylogenetic comparative methods to test the hypothesis that the inner ear shape relates to spatial constraints in the skull imposed by potentially adaptive modifications such as increased relative neurocranial size for burrowing in fossorial taxa. We therefore reexamine a poorly-studied classical hypothesis and investigate its utility for predicting ecology in the fossil record, whilst also providing necessary context and novel hypotheses for future paleontological reconstructions in early-diverging toxicoferans.

**Funding Sources** Laidlaw Fellowship, Columbia Work Exemption Program Grant, NSF GRFP Grant No 1938103, Richard Gilder Graduate School, the Carter Fund, Yale Biospheric Studies Early Grant

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Romer Prize Session (Thursday, October 19, 2023, 8:00 AM)

**CORRELATIONS BETWEEN DEGREE OF AXIAL AND APPENDICULAR CHANGE, DERIVED SWIMMING STYLE, AND ANCESTRAL TERRESTRIAL STATE IN SECONDARILY AQUATIC AMNIOTES**

Formoso, Kiersten K.

Earth Sciences, University of Southern California, Los Angeles, California, United States

Secondarily aquatic (SecAq) amniotes are excellent models for studying dramatic locomotor shifts. However, assessment of locomotor transformation in these clades is rarely viewed from the terrestrial starting point despite distinct functional and morphological differences which separate these clades at the onset of their transitions, particularly between mammals and reptiles (e.g., sprawling versus upright postures, and vertebral bending orientation). Further, ventures to compare the evolutionary pathways across transitioning marine mammal and marine reptile clades are historically rare.

To directly compare the relative transformations in locomotion-relevant morphology across SecAq amniotes, I developed 18 functional proxy measurements across the axial skeleton, and 32 for the appendicular skeleton. I applied these measurements to 64 taxa from early transitioning SecAq clades spanning different ancestral terrestrial histories from across the Mesozoic and Cenozoic. Using the closest known terrestrial outgroup for each clade, an approximated functional ancestral terrestrial state (ATS) was estimated using these measurements. Then, the degree of appendicular and axial divergence from the ATS was determined for each clade using phylomorphospaces generated using the R package, Claddis.

Within each clade, my results show that mosasauroids and sauropterygians had the most extreme differences in change across their skeletons with mosasauroids' axial skeleton changing 1.8 times more than their appendicular skeleton, despite already starting their transitions as axial swimmers. Early sauropterygians changed their appendicular skeleton 2.65 times more than their axial skeleton, and likely transitioned from axial to appendicular swimming. Across clades, sauropterygians and pinnipedimorphs, differing in ATS, but convergent in appendicular swimming style, are the most constrained in their axial skeletons. Mosasauroids changed the most in their axial skeleton, followed by cetaceans—potentially revealing their transition from appendicular paddling to axial swimming. These results suggest that the degree of skeletal change in SecAq transitions is more correlated with derived swimming style than with starting ATS, even for clades that start off seemingly suited to one type of swimming (e.g., mosasaurs and axial swimming) indicating that more extrinsic rather than intrinsic factors drive the trajectories of these transitions at least as reflected in skeletal morphology.

**Funding Sources** National Science Foundation (GRFP), Society of Vertebrate Paleontology (Wood Award), Society of Integrative & Comparative Biology (FGST)

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Technical Session 4: Dinosaur Soft Tissues (Wednesday, October 18, 2023, 1:45 PM)

### NON-AVIAN THEROPODS DID NOT HAVE LATERALLY-WRAPPING PTERYGOIDEUS MUSCLES

Fortner, John D.[1], Sellers, Kaleb[2], Holliday, Casey[1]

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All vertebrate skulls are under significant feeding-related selective pressures. Their jaw musculature must generate sufficient force to seize and/or process food, while their skull bones must withstand feeding stresses. While we have a good idea where most jaw muscles in archosaurs attach, *m. pterygoideus ventralis* (mPTv) poses a particular challenge. Dinosaurs like *T. rex* are often reconstructed with crocodilian-like laterally-wrapping pterygoideus muscles, which are hypothesized to resist long-axis rotation of the mandible. We evaluated specimens for osteological correlates of this muscle attachment and found equivocal signal. Extant phylogenetic bracketing is equally equivocal. Without clear osteological or phylogenetic support for an attachment site, we resorted to mechanical testing to determine mPTv's attachment site and role in skull function. We modeled *Alligator* and *Tyrannosaurus rex* with a laterally-wrapping and non-wrapping mPTv to analyze the relationships between muscle loads and skull forces. To mimic a laterally wrapping mPTv, we oriented contractile forces from its origin and insertion sites to the centroids of their wrapping areas, then applied the negative sum of those forces as a point load to the centroid. In *Alligator* with laterally wrapping mPTv, the muscle's resultant passes through the jaw joint. Jaw joint reaction forces are lower than in models without a laterally wrapping mPTv, though this slightly reduces bite force. In *T. rex*, models with both laterally wrapping and non-wrapping mPTv have muscle resultants passing anterior to the jaw joint; however, non-wrapping mPTv models have only marginally higher jaw joint reaction forces and higher bite force than laterally wrapping models. The laterally wrapping mPTv of *Alligator* helps resist jaw joint tension and long axis rotation of the hemimandible. Theropods like *T. rex*, with their comparatively tall and narrow mandibles, evidently did not face this problem, as force resultants for all models were anterior to the jaw joint and thus contribute to bite force. We thus conclude that non-avian theropods likely did not possess crocodilian-like laterally wrapping pterygoideus muscles.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**DISTRIBUTION OF AMPHIBIANS IN THE MORRISON FORMATION (UPPER JURASSIC) OF THE ROCKY MOUNTAIN REGION, USA**

Foster, John R.[1], Hunt, Adrian[2], Kirkland, James I.[3], Hunt-Foster, ReBecca K.[4], Trujillo, Kelli[5]

[1]Utah Field House of Natural History State Park Museum, Vernal, Utah, United States, [2]Flying Heritage & Combat Armor Museum, Everett, Washington, United States, [3]Utah Department of Natural Resources, Utah Geological Survey, Salt Lake City, Utah, United States, [4]Dinosaur National Monument, Jensen, Utah, United States, [5]U-Pb Geochronology Lab, Department of Geology and Geophysics, University of Wyoming, Laramie, Wyoming, United States

Relatively little is known about the amphibian fauna of the Morrison Formation, although more about these animals has appeared in recent years. There are at least three species of frogs, representing pelobatids, discoglossids (*Enneabatrachus*), and rhinophryid pipoids (*Rhadinosteus*). Until the 1990s, frogs were known almost entirely from Quarry 9 at Como Bluff, Wyoming. Since then, they have been reported from a total now of 7 localities, including at least 33 individuals. Upper Jurassic frogs are known from southern Utah to northern Wyoming, ranging from 37.492 to 44.387 degrees modern latitude. Stratigraphically, the frog specimens are primarily found in the Brushy Basin Member or equivalent levels in Morrison undifferentiated (determined by radiometric age). Frog specimens occur mostly in greenish gray mudstone facies, but are also known in silty, laminated clayball conglomerates, and finely laminated lacustrine shales. Frogs occur in a recently reported bromalite at the Jurassic Salad Bar locality, and new SEM EDX analysis shows indeterminate material in the fossil (neither bone nor geologic matrix) is almost devoid of P but very high in C, suggesting the material is soft tissue preserved in the regurgitalite. Salamander fossils consist of at least two (and probably more) forms with a range of sizes, including cryptobranchoids (*Iridotriton*). Salamanders are now known from 10 localities and at least 23 individuals. Geographically, salamanders range from south to north the same degree as frogs, and in fact are known from the same site areas on each end. All salamander specimens appear to be from the upper levels of the formation, possibly all from the Brushy Basin Member or equivalent levels. Caudata may still be unknown from the older parts of the formation. Salamanders are found in the same range of pond facies as frogs and are found in five of the same sites. Despite their low numbers, amphibians are not as rare in the Morrison Formation as previously perceived. Amphibians are more abundant (by locality count) than cursorial crocodylomorphs, *Cteniogenys*, eutriconodonts, docodonts, paurodontids, and "symmetrodontans." By minimum number of individuals, amphibians are more numerous than pterosaurs, *Haplocanthosaurus*, *Brachiosaurus*, small theropods, and "symmetrodontans." The relative rarity of amphibians in the formation is likely due in part to collecting bias in favor of larger, less delicate vertebrates.

**Funding Sources** David B. Jones Foundation, University of Bonn

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Technical Session 11: Archosaurs (Friday, October 20, 2023, 8:00 AM)

**A NEW LOOK AT THE CRANIAL ANATOMY OF THE EARLY TRIASSIC RHYNCHOSAUR *MESOSUCHUS BROWNI*, WITH COMMENTS ON OLFACTORY EVOLUTION IN REPTILES**

Foster, William[1], Gensbigler, Paul[2], Wilson, Jacob D.[1], Lyson, Tyler[3], Bever, Gabriel S.[1]

[1]Center for Functional Anatomy and Evolution, Johns Hopkins School of Medicine, Baltimore, Maryland, United States, [2]Johns Hopkins University, Baltimore, Maryland, United States, [3]Denver Museum of Nature and Science, Denver, Colorado, United States

*Mesosuchus browni* is a pan-archosaur represented by a small series of specimens collected from Early Triassic sediments of the Karoo Basin, South Africa. Known specimens are housed in the Iziko South African Museum in Cape Town and include an exceptionally preserved skull (SAM 6536) that Robert Broom considered one of the finest specimens known to vertebrate paleontology. A detailed description of *Mesosuchus* skeletal anatomy using a traditional approach is published and was followed by a microCT study targeting the SAM 6536 braincase. Here, we build on these efforts by extending the benefits of advanced imaging to the remainder of SAM 6536. Justification for these efforts is drawn from the heuristic potential of the specimen as reflected in its overall preservation, the striking resolution of the resultant CT images, and the strategic phylogenetic position in which *Mesosuchus* is commonly recovered. As an early-diverging rhynchosaur, *Mesosuchus* is critical for polarizing characters and testing evolutionary and phylogenetic hypotheses, both within Rhynchosauria and along the

phylogenetic backbone that produced crown Archosauria.

The high-resolution data permit the identification of previously inaccessible anatomical variation while confirming the overall accuracy of previous descriptions. Access to the deep surface of the dentary, for example, confirms the plesiomorphic presence of a centrally positioned Meckelian groove as opposed to the derived ventral restriction of this groove found in numerous crown archosaurs. The presence of a coronoid bone is now confirmed, contributing to a plesiomorphic low mandibular profile that is transformed in other rhynchosaurs as a prominent coronoid process. Internal details of the cranial roof reveal a number of intriguing morphologies whose phylogenetic and evolutionary implications are not yet clear. These range from the nature of various bony sutures to the presence of a laterally expanded olfactory bulb. This expansion is of note given that we also find evidence of a fully formed vomeronasal sensory system, which is inferred in part based on a previously undescribed and deeply sculpted septomaxilla. The coexistence of these osteological correlates adds to the complex story of neurosensory evolution in the deep history of archosaurs and provides an opportunity for integrating the fossil record with emerging genomic patterns of olfactory and vomeronasal evolution.

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Technical Session 8: Mammal Paleoecology (Thursday, October 19, 2023, 1:45 PM)

**REASSESSING THE NEOGENE HISTORY OF $C_4$ GRASSES IN THE GREAT PLAINS, U.S.A.**

Fox, David L.[1], Lukens, William[2]

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Multiple lines of evidence indicate the origin of the modern grassland ecosystems in the Great Plains of North America proceeded in two stages. Plant microfossils (phytoliths) indicate that open, grass-dominated habitats first appear around the Oligo-Miocene boundary and included grasses using the $C_3$ photosynthetic pathway, with $C_4$ grasses emerging later in the Miocene to Pliocene. Stable carbon isotope ratios ($\delta^{13}C$ values) from tooth enamel of large-bodied mammalian herbivores largely support this model, with the first $C_4$ consumers first evident by 6.6 Ma in Texas and then at ca. 6.25 Ma in Nebraska. However, pedogenic carbonate $\delta^{13}C$ values are consistent with $C_4$ grasses being present since at least 23 Ma, broadly coincident with the first phytolith evidence for open habitats. Key to the different interpretations of the $\delta^{13}C$ data are the assumed endmember $\delta^{13}C$ values for $C_3$ and $C_4$ plants in the past and whether and how measured $\delta^{13}C$ values are interpreted as fraction $C_4$ biomass ($f_{C4}$). Here we reinterpret published carbon isotope records from the Neogene and Quaternary of Nebraska using a global compilation of modern plant $\delta^{13}C$ values and a Monte Carlo method for estimating $f_{C4}$ from measured $\delta^{13}C$ values. This approach applies linear mixing that accounts for natural variation in plant endmembers and uncertainties in the $\delta^{13}C$ of atmospheric $CO_2$ and the fractionations associated with pedogenic carbonate and bioapatite. For a measured $\delta^{13}C$ value, the MC method generates a distribution of 10,000 $f_{C4}$ values that allows for statistical assessment of the $C_4$ component. We focus on Nebraska records for their long duration and to minimize the role of latitudinal diachroneity in increased abundance of $C_4$ grasses. For published carbonate $\delta^{13}C$ values with ages 23.0-7.25 Ma (n=115), 90.4% have median $f_{C4}$ values >0, and for 85 samples across the entire age range, the 5$^{th}$ percentile of the $f_{C4}$ distribution is positive. For published $\delta^{13}C$ values of mammals with ages 18.25-0.5 Ma (n=537), 98.5% have median $f_{C4}$ values >0, including one specimen at 18.25 Ma; for 235 of the specimens, including 165 Miocene specimens with ages 16.5-0.5 Ma, the 5$^{th}$ percentile of the $f_{C4}$ distribution is positive. Our results provide statistical support for the original interpretation of the Miocene carbonate record from the Great Plains and indicate that large-bodied mammals in the region were consuming $C_4$ grasses during the Early Miocene, much earlier than heretofore recognized.

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Preparators' Session (Thursday, October 19, 2023, 8:00 AM)

**NO SAW SUPPORT JACKETS**

Fox, Marilyn, Lutz, Christina, Lash, Catherine

Yale Peabody Museum, New Haven, Connecticut, United States

Many large or fragile specimens require jackets, cradles, clamshells or other plaster and fiberglass supports. The method most used is to layer plaster and fiberglass well over the edges of the specimen, wait until the plaster is dry, remove the specimen, and saw off the edges. This is a dusty process, requiring appropriate PPE to avoid breathing harmful flying plaster and fiberglass dust, as well as hearing and eye protection. It should be performed with a vacuum or dust collector. It can leave fiberglass splinters sticking out of the rough jacket edges, requiring either covering with an additional layer of plaster or even blowtorches. Fiberglass splinters in hands, and the annoyance and damage from plaster and fiberglass supports are the subject of many methods discussions among preparators and collections staff.

Here at the Yale Peabody Museum, we use a technique which eliminates the step of sawing the edges of our support jackets. We simply stop applying the fiberglass approximately one-half inch (or 1cm) inside of the planned edge of the jacket. We continue plastering that last ½ inch around the edge manually making a nice, rounded edge. This method works for any kind of jacket, cradle or clamshell. Either Hydrocal or Hydrocal FGR 95 work well with this method. As a barrier between the plaster and the specimen we have used felt, ethafoam, or a clay layer that is replaced with ethafoam. We primarily use continuous strand mat, but we have also used fiberglass veil, fiberglass fabrics and fiberglass scrim purchased from Fibre Glast. Once the plaster has set, but before it is fully dry, the jacket is lifted from the specimen and the edge is cleaned up quickly with a Sur-Form.

This method does require some understanding of the properties of plaster and how to work with them. For example, as the plaster sets and thickens it can be used to build up any thin sections around the edge. It can be smoothed with spatulas or hands with a bit of water. Tools used include silicone mixing bowls, spatulas - a variety of small and large metal and plastic tools, and Sur-Form tools (this tool consists of a steel strip with holes in a handle; one side of the hole is sharpened to make a cutting edge). The preparator should, of course, use appropriate PPE, such as N95 masks, gloves, and eye protection when working with plaster and fiberglass.

The edge is as sturdy as a cut edge, easier and cleaner to achieve, and much less aggravating.

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Virtual Posters

## NEW EVIDENCE SUGGESTS THAT *DEINOSUCHUS RIOGRANDENSIS* SHOULD FORM THE TYPE SPECIES OF *DEINOSUCHUS*

Fox-Pendergrast, Lillian A., Cossette, Adam P.

Biomedical and Anatomical Sciences, NYITCOM-AR, Jonesboro, Arkansas, United States

To preserve stability in the taxonomy of alligatoroid crocodylians, the undiagnosable *Deinosuchus hatcheri* known from a single, highly incomplete specimen (consisting of two vertebrae, one cervical rib, one dorsal rib, fragments of dorsal ribs, one pubis, 27 complete or nearly complete osteoderms, and a number of indeterminate fragments) should be replaced as the type species of *Deinosuchus*. The well-represented nominal species *Deinosuchus riograndensis* also from the Campanian of the western interior of North America is the best species to serve as the replacement. A recently published phylogenetic analysis recovered five unambiguous synapomorphies for the genus *Deinosuchus* and six unambiguous autapomorphies for the species *D. riograndensis*, in its current usage. Additionally, this analysis found that the *D. hatcheri* holotype preserves a single character diagnosing the genus. A recently described specimen indicates that *D. hatcheri* is itself diagnosed by an autapomorphy now known to be shared with another species of *Deinosuchus*. We consider *D. hatcheri* a nomen dubium and this is problematic because the name *Deinosuchus* is deeply established in both professional and popular media. However, *D. riograndensis*, a species known from several well-represented individuals from the Campanian Aguja Formation of Big Bend National Park in southwest Texas has generally been used as the reference species for studies of comparative anatomy and phylogeny of the genus, and casts of its holotype and specimens from its type locality, are held in repositories around the world. *Deinosuchus riograndensis* preserves all five synapomorphic characters diagnosing the genus and is the best available species to replace *D. hatcheri* as the type species of *Deinosuchus*. This allows for the preservation of *Deinosuchus* as a taxonomic name with generally accepted content and for the differentiation of the two species of *Deinosuchus* evident in the fossil record of North America.

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Technical Session 17: Afrotheria & Mammal Macroevolution (Saturday, October 21, 2023, 8:00 AM)

**APPROXIMATING MAMMAL FUNCTIONAL TRAIT DIVERSITY USING BODY MASS**

Fraser, Danielle[1], Balk, Meghan A.[2], Doby, Joshua R.[3], Hopkins, Samantha[4], Pineda-Munoz, Silvia[5], Reuter, Dana[4], Shupinski, Alexandria[6], Villasenor, Amelia[7], Emery, Kitty F.[3], FuTRES, Functional Diversity Project Group[3]

[1]Palaeobiology, Canadian Museum of Nature, Ottawa, Ontario, Canada, [2]Naturhistorisk Museum, Oslo, Norway, [3]Florida Museum of Natural History, Gainesville, Florida, United States, [4]University of Oregon, Eugene, Oregon, United States, [5]Amazon Conservation Association, Washington, District of Columbia, United States, [6]University of Nebraska-Lincoln, Lincoln, Nebraska, United States, [7]The University of Arkansas, Fayetteville, Arkansas, United States

Quantifying biodiversity (i.e., the numbers and types of organisms) in the past and present enables us to illuminate patterns in the spatial distributions of species, to identify conservation “hot spots,” and, ultimately, to assess change resulting from both anthropogenic and non-anthropogenic processes. The various metrics for Functional Diversity (FD) attempt to describe the array of lifestyles occupied by species in the same assemblage. They rely on measuring or scoring ecologically relevant traits (e.g., diets) to quantify how species are distributed in ecological niche space. Frequently, FD is compared among modern communities separated in space but has also been applied to the fossil record. Much of the taxonomically informative mammal fossil record, however, consists of incomplete specimens, meaning some traits are not observable. Fortunately, body mass is a fundamental mammalian trait correlated with many other components of mammalian ecology. It is also easily estimated from both dental and postcranial remains from the fossil and sub-fossil records and available from modern biodiversity databases. The objective of the present study is to investigate whether FD calculated using body mass alone is representative of mammalian FD incorporating other ecologically relevant traits. Using distribution data for terrestrial mammals from IUCN and trait data from the FuTRES and COMBINE databases, we calculated FD over ~17,000 global grid cells covering all terrestrial modern environments. We calculated FD metrics using body mass alone and using other combinations of traits to compare spatial patterns visually and with spatial regressions. All models identified latitudinal gradients in FD, but gradients calculated using body mass alone were generally weaker. However, all models, including those using body mass alone, identified similar areas of high and low functional diversity with the tropics representing hotspots of functional richness and functional dispersion and the Arctic a hotspot of functional evenness. We suggest that body mass is useful for studying dynamics of FD in deep time, but that those changes may be dampened in magnitude. Notably, the inclusion of a metric for diet, often estimable from dental remains (e.g., 3D tooth shape), may enhance the detectability of comparatively small FD changes. An understanding of which traits infer changes in FD spatially will aid paleontologists in selecting informative traits and interpreting temporal change.

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Technical Session 12: Methods & Paleohistology (Friday, October 20, 2023, 8:00 AM)

**COMPARATIVE OSTEOHISTOLOGY OF THERIZINOSAURIA: IMPLICATIONS FOR THE EVOLUTION OF LARGE SIZE IN HERBIVOROUS THEROPODS**

Freimuth, William J.[1], Hedrick, Brandon P.[2], Liao, Chun-Chi[3], Zanno, Lindsay E.[4]

[1]Department of Biological Sciences, North Carolina State University, Raleigh, North Carolina, United States, [2]Department of Biomedical Sciences, Cornell University, Ithaca, New York, United States, [3]Key Laboratory of Vertebrate Evolution and Human Origins of Chinese Academy of Sciences, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, China, [4]Paleontology, North Carolina Museum of Natural Sciences, Raleigh, North Carolina, United States

Changes in the rate and duration of growth (heterochrony) produced the vast disparity of body sizes we observe among non-avian theropod dinosaurs. Osteohistological studies demonstrate that large-bodied theropods (e.g., >1000 kg) evolved via rapid increases in growth rates (acceleration) and extended periods of growth (prolongation). However, to date, these studies largely stem from hypercarnivorous taxa; a dearth of osteohistological and growth data exists for clades that evolved large size and spanned the omnivory–herbivory spectrum. As a result, potential relationships between ecomorphological shifts and growth rates or metabolic proxies in theropods are poorly understood.

Here, we investigate the osteohistological features of Therizinosauria with a focus on two North American taxa—the early-branching, small-bodied *Falcarius utahensis*, and the late-branching, large-bodied *Nothronychus graffami*. We compared a full circumferential humeral midshaft section for each taxon. The *F. utahensis* section (NCSM 33529A) reveals plexiform to circumferential vascular canals in the inner to mid-cortex. A total of 4–5 cyclical growth marks (CGMs) (lines of arrested growth (LAGs)) are present. In the outermost cortex, an abrupt transition from fibrolamellar to lamellar bone, a decrease in vascular density, and an external fundamental system (EFS) of 6–8 CGMs are suggestive of skeletal maturity. The presence of a humeral EFS contrasts with sub-adult microstructural features of a large femoral dataset of *F. utahensis*. The *N. graffami* humeral midshaft section (UMNH VP 16420) possesses six single LAGs, along with one double- and one triple-LAG complex. Several features suggest an advanced ontogenetic stage for this individual, including patches of secondary osteons throughout the inner cortex, a transition from circumferential to longitudinal vascular canal orientation towards the outer cortex, and an EFS composed of eight CGMs in the outermost cortex. Based on the circumference of the associated femur, an adult body mass for *N. graffami* is estimated at ~1200 kg.

The histologically mature humeri of these taxa permit modeling of growth trajectories and establish a framework to assess broader histological patterns in Therizinosauria. Ongoing investigations through a greater taxonomic sample provide insight into the evolution of growth strategies and their bearing on ecomorphological shifts in this clade.

**Funding Sources** This material is based upon work supported by the National Science Foundation award #1925973 to LZ.

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Technical Session 13: Fishes - Actinopterygians (Friday, October 20, 2023, 1:45 PM)

**A NEW ACTINOPTERYGIAN FISH FROM THE MISSISSIPPIAN (SERPUKHOVIAN) OF ALABAMA CLARIFIES THE ANATOMY AND RELATIONSHIPS OF THE ENIGMATIC FAMILY PAPHOSISCIDAE**

Friedman, Matt[1], Figueroa, Rodrigo T.[1], Shell, Ryan[2], Peterman, David[3], Ciampaglio, Chuck[4]

[1]University of Michigan, Ann Arbor, Michigan, United States, [2]Cincinnati Museum Center, Cincinnati, Ohio, United States, [3]Penn State University, State College, Pennsylvania, United States, [4]Wright State University, Dayton, Ohio, United States

The Mississippian represents an important interval in the evolution of actinopterygian (ray-finned) fishes, with the appearance of novel body forms and dental structures that suggest new ecological and functional variety. A handful of sites yielding articulated fossils provide key snapshots of this episode in actinopterygian history. In North America, the most prominent assemblage is the Serpukhovian Bear Gulch fauna of Montana, which yields over 30 genera of actinopterygians. These include members of several anatomically specialized families endemic to the locality and of unclear relationships. Here we report an incomplete ray-finned fish fossil from the coeval Bangor Limestone of northwestern Alabama, representing the first intact Carboniferous actinopterygian reported from the region. This diminutive specimen preserves a partial postcranium including articulated trunk squamation, dorsal and anal fins, and pectoral girdles. The skull bones are largely disarticulated. The fossil shows high contrast in micro-computed tomography scans, permitting the individual dissection and investigation of three-dimensionally preserved bones and scales. The specimen from Alabama shares a combination of features with the peculiar Paphosiscidae, previously represented by two species of *Paphosiscus* known only from Bear Gulch. These traits include: pore-bearing enamel covering dermal bones; enlarged ridge scales anterior to the dorsal fin; a long-based dorsal fin; a subopercle that is larger than the opercle; reduced marginal dentition; principal mandibular dentition borne by the coronoids; short and deep lower jaw; reduced dentary; trapezoidal maxilla; and cleithrum strongly constricted at the level of the pectoral-fin articulation. The unusual aspects of the jaws and dentition correspond to conditions apparent in some taxa assigned to the Carboniferous-Permian Eurynotiformes, providing evidence that paphosiscids might be closely related to–or fall within–this clade. More generally, results point to the potential of tomographic approaches to yield significant data from disrupted or otherwise overlooked early ray-finned fish material.

**Funding Sources** NSF EAR 2219007 (to MF)

Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**MORPHOLOGY AND SYSTEMATICS OF LATE CRETACEOUS LUNGFISHES FROM MADAGASCAR**

Fuller, Brian[1], Ramón, Alfonsina[2], Claeson, Kerin[2]

[1]Cabrini University, Radnor, Pennsylvania, United States, [2]Philadelphia College of Osteopathic Medicine, Philadelphia, Pennsylvania, United States

Extant lungfish (Dipnoi), lepidosirenids, protopterids, and neoceratodontids, are endemic to South America, Africa, and Australia respectively. Prior to the Late Cretaceous, these landmasses contributed to the southern supercontinent Gondwana, as did Madagascar, which separated from Africa in the Late Jurassic, but only became fully isolated as an island when it separated from the Indian subcontinent about 88 mya. Extinct dipnoans were much more cosmopolitan in their current distribution, with abundant records also in Laurasia. Beginning in 1993, field teams led by Stony Brook University, and more recently by the Denver Museum of Nature & Science and Ohio University, recovered a large assemblance of Late Cretaceous fossil vertebrate specimens from the Mahajanga Basin in northwestern Madagascar. In addition to a much larger, relatively diverse sample from the Maastrichtian Maeverano Formation, several hundred specimens were also retrieved from the Ankazomihaboka beds, which are of Coniacian or Santonian age (~90 – ~84 mya). Approximately half of the Ankazomihaboka specimens (~300) are dipnoan tooth plates preserved on prearticular and pterygoid jaw bones. Tooth plates were compared to extinct and extant genera of lungfishes, including †*Ferganaceratodus* and †*Ptychoceratodus*, which these specimens were previously identified to be. We scored these specimens into a previously published matrix to test these hypotheses using PAUP. †*Ptychoceratodus* would support an affinity with Triassic and Jurassic species found in India and Madagascar (e.g., †*P. hislopianus,* †*P. cf. hislopianus*, and †*P. acutus*). †*Ferganaceratodus* would be significant due to its Jurassic presence in Kyrgyzstan and Thailand. Our results indicate the Late Cretaceous Madagascar specimens are more closely related to †*Ceratodus* than to any other genus. This implies the possible presence of a ghost lineage, and that a lungfish population of lungfishes were likely present in Madagascar long before the Late Cretaceous.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**PROBING THE DISTINCTIVE PREMOLARS OF PENTACODONTIDS (EUTHERIA: MAMMALIA)**

Fulwood, Ethan

Anatomy, DeBusk College of Osteopathic Medicine, Lincoln Memorial University, Knoxville, Tennessee, United States

The enigmatic eutherian family Pentacodontidae comprises a small number of relatively poorly understood but ecologically interesting species from the Paleocene of North America and Europe. Several pentacodontids exhibit relatively enlarged last premolars, a condition most pronounced in the best known pentacodontid species, *Aphronorus orieli*. Explaining this distinctive premolar morphology poses a functional problem. Enlarged premolars may represent an adaptation for crushing high diameter food items, as these teeth can be brought to bear on hard objects at higher gapes than at the more distal molars. This is consistent with the malacophagous diet hypothesized for *Aphronorus orieli*. Adaptation for exerting crushing pressures with the premolars should predict a correlation between premolar size and the mechanical potential at the largest premolar's bite point. To test this prediction, I measured lower fourth premolar lengths and calculated mechanical potential at the lower fourth premolar bite point using lateral photographs of a sample of mandibles from 14 species of extant erinaceids and CT scans of *Aphronorus orieli*. The erinaceids match in size and potential dietary ecology the relatively generalized Paleocene pentacodontids. Analyses were performed in Bayesian multilevel framework implemented in BRMS in R. To better clarify taxonomic relationships within Pentacodontidae, I also coded three species of *Aphronorus* and representatives of the genera *Bisonalveus*, *Coriphagus*, *Eurolestes, Pentacodon*, and five potential outgroups into a published taxon-character matrix which emphasizes premolar morphology and assessed their phylogenetic relationships using maximum parsimony implemented in PAUP. Contrary to expectations, fourth premolar length was not strongly related to mechanical potential (beta parameter = 0.2 [-0.05 : 0.10 95% CI]). This may suggest that premolar

length is driven by functional demands other than crushing force, or potentially represent limitations in measurements of bite force from dry mandibles without muscle information. Pentacodontids and the genus *Aphronorus* were recovered as natural groups with a split between the European *Eurolestes* and the remaining North American taxa at the base of the family.

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Technical Session 5: Ungulates (Wednesday, October 18, 2023, 1:45 PM)

## EVIDENCE OF DISPARATE LIFE HISTORIES IN THE PALAEOCENE RISE OF EUTHERIA

Funston, Gregory F.[1], Holpin, Sofia[2], Shelley, Sarah[2], Williamson, Thomas[3], Brusatte, Stephen[2]

[1]Natural History, Royal Ontario Museum, Toronto, Ontario, Canada, [2]School of GeoSciences, University of Edinburgh, Edinburgh, Scotland, United Kingdom, [3]New Mexico Museum of Natural History and Science, Albuquerque, New Mexico, United States

The early Palaeocene (66–61.6 mya) witnessed the establishment of mammal-dominated terrestrial ecosystems after the extinction of the non-avian dinosaurs. Understanding the mammals that formed these communities is crucial not only for disentangling the origin of living mammal clades, but also the forces that structured these first precursors of modern ecosystems. The potential role of life history as a driving factor in the composition of early mammalian ecosystems has long been appreciated but has historically been difficult to evaluate. A central focus thus far has been on differences in reproductive strategy between three major North American mammal clades, specifically multituberculates, metatherians, and eutherians. However, virtually no work has considered whether reproductive strategy was uniform within these clades. Recent advances combining paleohistology with geochemistry have opened a new window into reproduction in extinct mammals, revealing a highly precocial lifestyle in the eutherian pantodont *Pantolambda*, but it is unclear whether this life history style characterized early eutherians more broadly. Results from another eutherian, the phenacodontid *Tetraclaenodon*, challenge this notion. Both cementochronology and osteohistology indicate a drastically slower life history in the slightly smaller *Tetraclaenodon*, at virtually the opposite end of the eutherian spectrum from *Pantolambda*. After a relatively short gestation period (~2 months), *Tetraclaenodon* retained slow-growing deciduous teeth for as long as four years. The oldest individual in our sample grew exceptionally slowly towards the end of its life, which spanned at least 8–9 years. The ratio of gestation period to body size (10–15 kg) in *Tetraclaenodon* is similar to small-bodied carnivorans like the coyote (*Canis latrans*), Caracal (*Caracal caracal*), and African civet (*Civettictis civetta*). However, these extant species vary significantly in the duration of suckling (1.5–4 months), and therefore total maternal investment. Determination of the closest modern analogue for *Tetraclaenodon* awaits geochemical work to reconstruct nursing patterns. Nonetheless, these results indicate that eutherian life histories were already diverse in the early Palaeocene and raise doubts that more precocial “placental”-style reproduction is solely responsible for the greater proliferation of eutherians than other mammal clades during this interval.

**Funding Sources** Natural Sciences and Engineering Research Council of Canada, Vanier-Banting Commission, European Research Council

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Technical Session 5: Ungulates (Wednesday, October 18, 2023, 1:45 PM)

## GROUNDS FOR COMPARISON: SPATIAL TRENDS IN THE UTILIZATION OF SHED CARIBOU ANTLERS AS MINERAL RESERVES

Gaetano, Madison[1], Miller, Joshua H.[1], Wald, Eric[2], Druckenmiller, Patrick S.[3]

[1]Geosciences, University of Cincinnati, Cincinnati, Ohio, United States, [2]Arctic Network-Inventory and Monitoring Division, National Park Service, Fairbanks, Alaska, United States, [3]University of Alaska Museum of the North, University of Alaska, Fairbanks, Fairbanks, Alaska, United States

Caribou (*Rangifer tarandus*) are the only extant deer species in which females produce antlers. Male antlers contribute to reproductive success through display and combat, however there is little consensus regarding the evolutionary drivers of female antlers. While male antlers are shed starting in the fall and often on a herd’s mating grounds, antlers of pregnant females are shed during the spring birthing interval on a herd’s calving grounds. Though forage analyses of spring and summer caribou ranges indicate

deficiencies in key minerals (calcium and phosphorus) to support nursing females, assemblages of mineral-rich shed female antlers are readily available. Here, we test the novel hypothesis that female caribou antlers provide mineral supplements for nursing females. Using antler and skeletal material collected from calving and mating grounds (Porcupine Caribou Herd; Arctic National Wildlife Refuge, Alaska), we documented patterns of consumption by co-occurring ungulates (*Rangifer*), carnivorans *(Ursus*, *Canis*, *Vulpes)*, and rodents *(Urocitellus*, *Microtus)*. To assess whether the nutrient stresses associated with spring calving elevate reliance on antler consumption, we compared modification by known taxa on spring calving grounds and fall mating grounds. Standardized bone surveys of calving grounds (n=53) and mating grounds (n=7) yielded over 1,300 antlers and several hundred skeletal bones. We found caribou gnawing on ~90% of antlers shed on spring calving grounds, but <10% of co-occurring skeletal material. Further, less than 30% of antlers sampled from fall mating grounds were gnawed on by caribou. Additionally, while <3% of antlers shed on calving grounds are modified by rodents, they are the most prolific consumer of mating ground antlers (~40% recorded rodent gnawing). Caribou monopolize the consumption of shed antlers on the calving grounds, likely driven by nursing females experiencing the compounding demands of lactation, antler regrowth, and migration. The drive to consume antlers is also strongest on the calving grounds, suggesting that a key fitness benefit of female antlers could be that of a post-natal nutrient supplement. Antlers can reach high concentrations on Arctic calving grounds (>1,000 antlers/km$^2$) and persist for centuries or longer. Annual use of calving grounds, during which females consume available antler resources and contribute their own, may function as an unrecognized feedback mechanism promoting fidelity to calving grounds.

**Funding Sources** University of Cincinnati Sigma Xi and Office of Research; Geological Society of America; American Philosophical Society; University of Alaska Museum of the North

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

### DIPPY LONGSTOCKINGS: PRESENCE OF MELANOSOME IMPRESSIONS IN *DIPLODOCUS* SP. SCALES EXPANDS OUR KNOWLEDGE OF SAUROPOD COLORATION

Gallagher, Tess[1], Folkes, Dan[1], Schein, Jason[2], Storrs, Glenn W.[3], Vinther, Jakob[1]

[1]University of Bristol, Bristol, United Kingdom, [2]Elevation Science, Philadelphia, Pennsylvania, United States, [3]Cincinnati Museum Center, Cincinnati, Ohio, United States

Exceptional preservation of integumentary fossils has helped broaden our understanding of extinct fauna, especially in dinosaurs. Integumentary fossils can help us better understand the physiology, appearance, and ecological niche of these animals. The discovery of melanosomes and melanin in particular has made it possible to reconstruct the color patterning of certain dinosaur taxa, namely feathered dinosaurs. However, several scaly dinosaur taxa have also been found either with melanin or melanosome impressions. In this study, melanosome impressions found within the organically preserved polygonal scales of *Diplodocus* sp. are described. The scales originate from the Mother's Day quarry and are preserved as a carbonaceous film, with the scales measuring ~1.5 cm in diameter. The small size and rounded shape of the impressions indicate these may be phaeomelanosomes, suggesting a possible ginger or yellow color for these scales. While the exact coloration cannot be determined due to the fact that color producing cells such as chromatophores do not fossilize, the presence of phaeomelanosomes indicates that *Diplodocus* may have been more strikingly colored than previously realized, especially compared to the relatively dull colors seen in extant terrestrial megafauna.

**Funding Sources** University of Bristol, Department of Earth Sciences, Palaeobiology MSc program

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Colbert Poster Prize Session

### LOOKING FOR THE ROLE OF HYPSODONTY IN THE MANDIBULAR BIOMECHANICS OF THE OREDONTS (ARTIODACTYLA, MERYCOIDODONTIDAE)

Garcia-Lara, Sergio L., Tseng, Z. Jack

Integrative Biology, University of California at Berkeley, Berkeley, California, United States

Merycoidodontidae (oreodonts) were an abundant group of North American endemic artiodactyls during the middle Cenozoic. Oreodont taxa represent a range of tooth crown heights (hypsodonty), and thus serve as a useful model system for analyzing potential correlations between crown height and craniodental functional morphology. We analyzed groups of hypsodont and non-hypsodont oreodonts to test the hypothesis that degree of hypsodonty correlated with biomechanical characteristics of the oreodont mandible. The sample included Leptaucheniine oreodonts that conventionally are known as the most hypsodont oreodonts. We calculated mandibular force profiles in five interdental positions: p1/p2, p4/m1, m1/m2, m2/m3 and m3/ascending ramus, specifically comparing relative mandibular force (Zx/Zy) and maximum mandibular force (Zx/L and Zy/L in mm2). We observed similar mandibular force profiles regardless of hypsodonty level in each estimated metric. Zx/L and Zy/L decrease toward the mandibular symphysis. Relative mandibular force profile (Zx/Zy) shows decrease in the m2/m3-m3/ascending ramus segment, followed by a valley then an increase toward the mandibular symphysis. Overall, the mandibular force profiles mirror the estimated body size based on the m1 length rather than degree of hypsodonty. Xz/Xy values are higher in the symphysis and ramus regions than in the corpus, even though the lowest forces were generated in the former region (X/L) which may indicate that the caniniform premolars was not used for processing hard material or defense. Despite these apparent patterns, none are statistically significantly different between the studied taxa. The findings suggest that oreodont mandibular biomechanics may be decoupled from differences in tooth usage implied by hypsodonty; limited sample sizes may also mask more subtle biomechanical differences among the studied taxa. Ongoing and future research clarifying the link between hypsodonty and mandibular biomechanics in extant artiodactyls could provide the basis for evaluating whether oreodonts display an unusual pattern of tooth-mandible functional decoupling.

**Funding Sources** SGL wants to acknowledge to Fulbright-García Robles and CONACYT for providing funding to pursue graduate studies.

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Technical Session 4: Dinosaur Soft Tissues (Wednesday, October 18, 2023, 1:45 PM)

**SEEMINGLY MOODY: A HYPOTHETICAL RECONSTRUCTION OF THE EYE MUSCULATURE OF *BAJADASAURUS***

Garderes, Juan P.[1], Whitlock, John A.[2], Toledo, Néstor[3], Gallina, Pablo A.[1]

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Of the cranial musculature in extant archosaurs, several functional groups have been thoroughly analyzed, mainly those related to biting biomechanics and skull stability. In this sense, adductor and craniocervical musculature, have been primarily analyzed for inference in non-avian dinosaurs. Conversely, other cranial muscular groups, such as the hyoid musculature and the extrinsic eye musculature, have been shallowly explored. Of the latter, in Archosauria, *Alligator* has been described, while in Aves, *Buteo buteo*, *Ardea cinerea* and *Gallus gallus* have been described. Here we present the first inferential reconstruction of the extrinsic eye musculature for a diplodocoid sauropod dinosaur, *Bajadasaurus pronuspinax*, based on osteological correlates and extant phylogenetic bracketing. The eyeball was inferred to have a size of half of the rostrocaudal length of the eye socket parallel to skull roof, similar to the dimensions of the scleral rings of *Diplodocus* (CM 11161) and *Nemegtosaurus* (ZPAL MgD-I/9), and an interorbital cartilage septum was inferred. Six muscles have been reconstructed. The insertion of these on the eyeball are inferred to be placed on its medial surface, according to a conservative location of these regarding the major axes of the skull and positions in *Alligator*, *Buteo* and *Gallus*. The four *rectus* muscles attach their origins surrounding the foramen for CN II. The muscle *rectus dorsalis* attaches on the surface where the orbitosphenoid and laterosphenoid fuse, leaving a shallow concavity as an osteological correlate. Caudally, the *m. rectus lateralis* attaches on the dorsal surface of the basisphenoid, without leaving an osteological correlate. The *m. rectus ventralis* attaches to the edge of the basisphenoid, ventral to the foramen for CN II, leaving a depressed surface as an osteological correlate. The remaining *m. rectus medialis* is inferred to attach rostral to the foramen for CN II, on the caudal portions of the interorbital cartilage. Onto this cartilage, both *obliquus* muscles attach rostrally, the *m. obliquus dorsalis* on the dorsal area, and the *m. obliquus ventralis* on the rostroventral area. The inferred extrinsic eye muscular system in *Bajadasaurus* shows a configuration more similar to that on extant Aves than that of extant Crocodylia, based on the position of the origin of the *obliquus* muscles.

**Funding Sources** National Geographic Society Grant W465-16; PICT 2013-0704; PICT 2018-0094

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Colbert Poster Prize Session

**NEOSELACHIAN DIVERSITY THROUGH DEEP TIME**

Gardiner, Amanda[1], Cooper, Rebecca[2], Kocáková, Kristína[1], Villafaña, Jaime[3], Pimiento, Catalina[4], Silvestro, Daniele[2]

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Extant sharks, skates, and rays together with their recently extinct ancestors comprise Neoselachii, a cosmopolitan clade in Chondrichthyes with an evolutionary history beginning in the Early Triassic (~ 250 Ma). Previous studies agreed on their diversity patterns through time: a large increase throughout the Cretaceous led to their maximum observed diversity in the late Late Cretaceous (~ 72 Ma) before a sharp decline during the K-Pg mass extinction (66 Ma), followed by a small recovery in the Paleocene (~ 61.6 Ma), and relatively stable diversity from the Neogene (~ 13.82 Ma) to the present. However, our current understanding of neoselachian diversity is impaired by the inherently incomplete fossil record and numerous biases. Here, we use “DeepDive”, a novel method based on deep-learning Artificial Intelligence, combined with an unprecedented dataset of over 30,000 fossil occurrences, to estimate neoselachian diversity from the Cretaceous to the present while accounting for multiple biases in the fossil record such as sampling, preservation, and the Signor-Lipps effect. Our results agree with previous findings for the Cretaceous: significant growth throughout the Early and early Late Cretaceous (437%) followed by a large increase in the Santonian (55%; 86.3 Ma – 83.6 Ma), culminating in a peak of diversity before loss crossing the K-Pg boundary (-42%). Diverging from past studies, we find that recovery in the Paleocene (66 – 56 Ma) was larger than previously thought and led to a second peak in richness in the early Eocene (63%; 56 – 47.8 Ma). Excusing a small recovery in the Middle Miocene (11%; 13.82 – 11.63 Ma), decline is observed from the early Eocene until the present (-62%), with nearly half of species diversity lost in the last 12 myr. Our results expose previously unknown trends in neoselachian evolutionary history and indicate that the diversity of this ecologically essential clade, which today has over 37% of species at risk of extinction, is severely depleted in comparison to the past.

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**NEW OCCURRENCES OF LATE CARBONIFEROUS FOSSIL FISHES FROM WEST VIRGINIA, APPALACHIAN BASIN, U.S.A.**

Gardner, Nicholas[1], Bovis, Max[2], Engelman, Russell[3], Godlesky, Clinton[4], Hodnet, John-Paul M.[2], Shell, Ryan[5]

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Field reconnaissance in northern West Virginia has expanded the known diversity of vertebrate fossils from this portion of the Late Carboniferous Appalachian Basin (eastern United States). Investigation into previously known conodont and invertebrate-bearing exposures has resulted in the discovery of numerous, identifiable fish remains. Nearly the entire Glenshaw Formation is exposed at the section (Late Pennsylvanian, Kasimovian). The principal layer producing vertebrate fossils appears to be equivalent to the Cambridge Limestone of Ohio and the Nadine and Woods Run Limestones of Pennsylvania (*Streptognathodus gracilis* conodont biozone).

Chondrichthyan fossils are present as both spines and teeth. Durophagous and ichthyophagous taxa are represented. The fauna includes elasmobranchs like ctenacanthiforms (such as *Glikmanius* sp.) and xenacanthiforms (*Orthacanthus* sp.) along with euchondrocephalans such as cochliodontiforms (such

as *Deltodus* sp.), eugeneodontiforms (cf. *Agassizodus*), and petalodontiforms (such as *Petalodus* cf. *ohioensis* and a *Cholodus*-like janassid). Acanthodian remains are present, including spines referable to *Acanthodes*. Indeterminate osteichthyan material is also present in the form of isolated scales and teeth.

The xenacanthiform teeth would be surprising in an otherwise marine assemblage, as they represent an early marine example for a group that are more often present in freshwater horizons especially in the late Carboniferous-Permian. However, the presence of lignite, preserved fossilized wood (cf. *Cordaites*), and oolites suggest that the habitat was nearshore. Therefore, the presence of xenacanthiforms actually suggests a nearby freshwater influence.
Given that most vertebrate fossil yielding Pennsylvanian localities in West Virginia have never yielded such well-preserved, identifiable material or such a diversity of species, this locality warrants sustained future exploration.

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Technical Session 12: Methods & Paleohistology
(Friday, October 20, 2023, 8:00 AM)

**OSTEOHISTOLOGY OF TROODONTID METATARSALS FROM THE DINOSAUR PARK FORMATION (DPF): IMPLICATIONS FOR GROWTH, STRESS, AND UNDERSTANDING OF PATHOLOGY**

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Among the theropods in the Dinosaur Park Formation (DPF), troodontids are one of the most enigmatic. As they are known from largely isolated material, the identity of its members is uncertain. This has created confusion when referencing specimens of various sizes as we currently lack ontogenetic or taxonomic precision for the clade within the DPF. Additionally, troodontids have a combination of features that make them unique among theropods within the DPF fauna. One example is their unique foot morphology, which shows an arctometatarsus condition with a specialized raptorial claw like dromaeosaurids. While the biomechanics of the arctometatarsus have been studied broadly, the combination of this feature with a specialized raised medial ungual and the resulting stresses are poorly understood. Here we analyze the growth patterns, stress, remodeling, and pathologies observed in DPF troodontids over ontogeny using histological and statistical methods. Eleven specimens (3 MTIIs, 3 MTIIIs, and 5 MTIVs) across a broad range in absolute dimensions (length and circumference) from the Royal Tyrrell Museum of Paleontology (RTMP) were selected in order to account for ontogenetic changes. Using circumference measurements of annuli in conjunction with proximodistal linear measurements previously obtained, regressions were performed to describe growth trends. The metatarsals analyzed show consistent rates of growth, with some conforming to the annuli of larger non-associated elements. This close growth relationship between specimens suggests one species, or closely related species of troodontid are represented in the sample. Bone deposition patterns are consistent with biomechanical stress models of the arctometatarsalian condition, wherein secondary remodeling is concentrated posteriorly and along the contact surface of MTIII in MTII and MTIV. In addition to annuli, dual Lines of Arrested Growth (LAGs) are observed, and accumulation of regionalized LAGs are evident in the pathologic, usually larger, specimens suggesting stressors accumulated through life. One notable MTIV (associated with an MTII) shows additional bone deposition forming a callus outside the normal margin of the shaft and a heavily deformed distal end unlike anything observed in previous pathology surveys. Multi-LAGs towards the outer bone and the anterior and posterior margins in both metatarsals suggest this animal lived with the pathology for some time before succumbing to an unrelated death.

**Funding Sources** NSERC: Canadian Graduate Scholarships - Masters (CGS-M), Dinosaur Research Institute: DRI Student Project

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Technical Session 2: Early Mammals & Carnivora
(Wednesday, October 18, 2023, 8:00 AM)

**NEW FORELIMB DETAILS OF *EUROTAMANDUA*, PURPORTED ANTEATER FROM THE MIDDLE EOCENE OF MESSEL, GERMANY, REVEAL EXTRAORDINARY SIMILARITIES TO PALAEANODONTS (PHOLIDOTAMORPHA), NOT TO XENARTHRA**

Gaudin, Timothy J.[1], Rose, Kenneth D.[2], Rabenstein, Renate[3], Habersetzer, Jörg[3]

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Micro-computed tomography of the unique skeleton of *Eurotamandua joresi* Storch, 1981 (middle Eocene, Grube Messel)—described as the oldest myrmecophagid and the only known Old World xenarthran—reveals details of its skeletal anatomy that were previously obscured, enabling close comparative study for the first time. In this report we add new anatomical details on the forelimb, especially the manus. The scans have allowed us to reconstruct nearly the entire forelimb and almost every bone in three dimensions, excepting portions of the first and fifth digits, revealing exceptional specializations for scratch digging in nearly every element. These include numerous features that are strikingly similar to those of palaeanodonts, and to a lesser degree manids, but which contrast sharply with those of the xenarthrans *Tamandua* and *Dasypus*. As previously reported, specific resemblances to palaeanodonts include the shape and distolateral tilt of the humeral head and morphology of the humeral tuberosities, a V-shaped deltopectoral shelf and enlarged supinator crest on the humerus, a deep elongated olecranon process, broad semilunar notch and weak radial notch of the ulna, a short and stout radius, and exceptionally short and robust metacarpals and phalanges. To these features we now add the morphology of the scapular and secondary scapular spines; marked distal expansion of the radius and a sizable dorsal tubercle at its distal end; a sessile, medially-indented ulnar styloid process; a broad radial head with a distinct trochlear facet, a sizable dorsal tubercle on the distal radius; a twinned palmar tuberosity on the scaphoid; a medially notched lunate; a large trapezoid with a keeled distal surface; a well-developed extensor tubercle on metacarpal 3; highly distinctive proximal and distal articular surfaces on both metacarpals and phalanges, including a small but distinct distopalmar-facing distal keel on the metacarpals; and a shallow, elongated unfissured third ungual resembling that of other digging mammals. Forelimb anatomy provides strong evidence that *Eurotamandua* belongs to Pholidotamorpha, not Xenarthra. Preliminary phylogenetic analysis places *Eurotamandua* in an unresolved polytomy with palaeanodonts and the extinct Messel pangolin relatives *Eomanis* and *Euromanis.*

**Funding Sources** Humboldt Foundation Travel Grant (KDR); Bramblett Gift fund, UTC BGE dept (TJG); UTC Faculty Research and Development Award (TJG)

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

### ROBODINO: ADVANCES IN ROBOTICS AS APPLIED TO A PALEONTOLOGY INTERACTIVE DISPLAY

Gay, Robert J.[1], Bingham, Kyler[2], Berry, Matthew[2], Walker, Payton[2], Lopez, Juan Cortez[2], Deemyad, Taher[2]

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Animatronic dinosaurs have been used in outreach and museum displays for decades. These models, while popular with the public, are limited as they fail in anatomical accuracy or are unconvincing as replicas of past life. Some institutions have transitioned to human-powered models, but these can be bulky, expensive, require specialized training, or otherwise rely on materials or expertise that are not readily accessible. Using 3D printing, off-the-shelf materials, an open-source kinematic model from the Max Planck Institute, and an existing 3D model of a dinosaur skeleton (*Oryctodromeus cubicularis*) at the Idaho Museum of Natural History, we are producing a new robot that will allow us to overcome these prior limitations. This project will result in a self-balancing and walking display, nicknamed RoboDino.

The hindlimbs of RoboDino are based on BirdBot, a robot designed by the Max Planck Institute for Intelligent Systems. The BirdBot project developed an emu-based bipedal robot with mechanical joint coupling. BirdBot's leg mechanism is scalable, lightweight, and energy efficient. It uses two motors per leg, pulleys, and is loaded by spring-tendon networks. We are using elements from BirdBot as the basis for the hindlimbs in RoboDino. The bony anatomy of IMNH's existing *O. cubicularis* 3D model has been combined with elements from BirdBot within SolidWorks, with functionality digitally checked. The final assembly and actuation of the legs will occur in late 2023.

The non-locomotive elements of the RoboDino project include the head, neck, body, and tail. The torso is designed to be rigid and act as a housing for all electrical components, which is a compromise between biological reality and the needs of the systems used in locomotion. The head has an articulated mandible, actuated by a servo. The neck is operated by a two-pulley system to mimic the range of motion in *O. cubicularis*. For prototype purposes, the arms will remain static. Specimens of *O. cubicularis* at the IMNH show that its tail was encased in bundles of tendons which were often ossified. To model this, the tail is made up of PLA and TPU 3D printed plastics. Sections of the tail will be connected with screws and vinyl tubing as in the neck. This will allow the tail to sway during locomotion, as a reasonable reproduction of the mechanics of the biological tail. Final assembly will happen in early 2024 and will provide a true robotic dinosaur for use by the IMNH team for outreach and display.

**Funding Sources** Idaho Museum of Natural History, Idaho State University CPI program

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Paleontological Management Poster Session (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

## WAYAN'S WORLD: DIGITIZING (MOST OF) A STATE'S CRETACEOUS FOSSIL RECORD

Gay, Robert J., Krumenacker, L.J., Peecook, Brandon R.

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In early 2023 the Idaho Museum of Natural History (IMNH) began a project to digitize via laser scanning the majority of the state's Cretaceous (Albian-Cenomanian) fossil record. While Idaho's Cretaceous fossil record is not as extensive as some neighboring states (Montana, Wyoming, Utah), it is significant for this portion of the Cretaceous and hosts higher biodiversity than others (West Coast states, Nevada). Idaho's Cretaceous fossil record is primarily from the Cenomanian Wayan Formation, a high-energy fluvial system representing a higher paleoelevation environment than the roughly contemporaneous Cloverly Formation or the Mussentuchit Member of the Cedar Mountain Formation and provides insight into the earliest Late Cretaceous of North America. The fauna is dinosaur dominated, with several species of mammals, turtles, crocodilians, and fishes.

The impetus for this project began as IMNH staff developed plans for an exhibit on the Cretaceous of Idaho. Staff noted several needs that could be met by having digital models of Wayan specimens. These include: enhanced education and outreach tools and touchable exhibits with 3D printed models of specimens, updated skeletal mounts, virtual copies of the exhibit available online for viewing outside of the IMNH, data conservation of specimens on display in case of accident or theft in the gallery, and possible research use. The non-invasive and easily accessible nature of surface-scan digitization holds many benefits over traditional molding and casting, including cost and impact to specimens. It also allows for data exchange between the IMNH and the USDA Forest Service, whose specimens the IMNH holds in trust.

Permission was obtained from the USDA Forest Service to digitize and reproduce Wayan Formation fossils from the Caribou National Forest. A priority list was made of Wayan Formation fossils for scanning. While the Wayan Formation has a robust faunal list, many of the clades known are represented by dental remains. These small and shiny fossils do not produce usable scans and may be targets for microCT scanning at a later date. Fossils that have been fully prepared away from the matrix were given the highest priority for scanning, and completeness was prioritized, unless a fragmentary specimen provided unique anatomical or taxonomic information.

Altogether, this work represents an ambitious effort to work with agencies and share the entirety of a fauna, and a state's dinosaur record, with the public.

**Funding Sources** Idaho Museum of Natural History, USDA Forest Service (Caribou National Forest)

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

## AN ANALYSIS OF THE INNER AND MIDDLE EAR OF *MERYCOIDODON*

Gegner, Jay, Robson, Selina Viktor, Theodor, Jessica

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Merycoidodontids were a pig-like group of artiodactyls residing in North America during the late Paleogene and Neogene periods, where they likely inhabited woodland areas. Together with the more basal agriochoerids, merycoidodontids are part of Oreodontoidea, a highly speciose and disparate superfamily. Despite their prevalence in the fossil record, little work has been done on the auditory region of merycoidodontids. Using CT data from a basicranium of *Merycoidodon*, we volumized the inner and middle ear structures, including the auditory bulla, petrosal, and bony labyrinth. We have identified key features of the petrosal and we have used measurement of the semicircular canals and cochlea to make inferences about lifestyle.

The auditory bulla of *Merycoidodon* is small, thick-walled, and hollow, which is the basal oreodont condition. The overall profile of the petrosal is blocky and angular. The specimen lacks a main epitympanic wing but has a prominent lateral process of the epitympanic wing, which differs from the typical artiodactyl condition. Contrary to expectations, the subarcuate fossa is shallow, being comparable to that found in derived protoceratids and ruminants. The basicapsular groove is represented by concave indentations on both the basioccipital and petrosal, leaving a large channel which would have carried the inferior petrosal venous sinus. This is unusual in that most artiodactyls display an indentation on only one of these bones. When considering the bony labyrinth, the aspect ratio of the cochlea is large (> 0.55), which is thought to be a derived character in artiodactyls. The semicircular canals are also large given the body size (~19.8 kg), suggesting more agility than would be expected from a pig-like animal; the agility score (An average of 3.01 on a scale of 1-6) is slightly higher than that of an extant camelid. This may be a carryover from more basal oreodonts that had a semi-arboreal lifestyle, but more extensive sampling is required before this hypothesis can be tested.

**Funding Sources** NSERC Discovery Grant

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

## VERTEBRATE BIODIVERSITY IN THE LASALLE LIMESTONE (CARBONIFEROUS: PENNSYLVANIAN) OF THE AMERICAN MIDCONTINENT

Geiser, Richard[1], Shell, Ryan[2], Thomas, Jared[3], Davis, Mark[1]

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The LaSalle Limestone Member of the Bond Formation is a Carboniferous, Kasimovian-aged, carbonate unit in the central and northern portion of the Illinois basin. Previous work in this unit has revealed a community of chondrichthyans such as *Petalodus*, *Deltodus*, *Helodus*, and *Peripristus*. However, the presence of a chondrichthyan braincase of unknown taxonomic affinity suggests that this chondrichthyan community could contain additional species richness. Subsequent investigations by the authors in the LaSalle Limestone near Oglesby, Illinois have revealed the presence of other chondrichthyans in this community such as members of the genera *Helserodus*, *Ossianodus*, *Holmsella*, *Stethacanthus*, as well as other potential Ctenacanthiforms, Euselachians, Holocephalians, and osteichthyans. This improved faunal list for marine vertebrate communities at this region and time provides additional possible candidate organisms for the identity of the unknown neurocranium and serves to highlight a chondrichthyan ecosystem from a key time in the tectonic and environmental evolution of the seaways, estuaries, and basins of what would become the central portion of the continental United States.

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Technical Session 20: Marine Mammals & Bats (Saturday, October 21, 2023, 1:45 PM)

## ORIGIN OF FILTER-FEEDING IN MYSTICETI (MAMMALIA: CETACEA) REVISITED

Geisler, Jonathan H.[1], Beatty, Brian L.[1], Boessenecker, Robert[2]

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The past 20 years have witnessed the discovery of numerous toothed mysticetes, many with unexpected and highly specialized craniodental features. Individual studies have inferred the paleobiology of these extinct species and reinterpreted features of others, leading to very different hypotheses for the origin of filter-feeding. Some authors suggest that baleen-bearing whales evolved from toothless suction feeders, others advocate for a protracted period when species had teeth and baleen, and others suggest an intermediate stage of dental filtration between raptorial ancestors and baleen-bearing whales. In the present study, 45 character states distributed among 14 morphological characters were interpreted as being supportive, neutral, or contradictory evidence to the following modes of aquatic feeding: raptorial, suction-feeding, baleen filtration, and dental filtration. All features were equally weighted, and evidence was summed to create a single score for each feeding hypothesis per taxon. Using this schema, the feeding behaviors for 114 mysticetes were calculated, and the feeding behaviors of hypothesized ancestors along the mysticete stem were inferred across of a suite of phylogenetic hypotheses. The feeding for 27% of the species could not be inferred, mostly due to missing data. There was good evidence for raptorial feeding in 13 species, including coronodonids, an interpretation also supported by dental wear patterns in recently described specimens of *Coronodon havensteini* and *C. planifrons*. By contrast, we found marginal evidence for specialized suction feeding in only two taxa (i.e., *Mammalodon*, *Mystacodon*), and other specimens with putative suction feeding wear were excluded because their phylogenetic positions have yet to be determined. From an evolutionary perspective, the inferred raptorial score on the internal branches leading to Crown Mysticeti drops at the origin of Neoceti and continues to decrease along the mysticete stem. On trees with coronodonids as basal mysticetes, this decline coincides with an increase in the evidence for dental and/or baleen filtration, suggesting individual species used multiple forms of feeding. However, when coronodonids are placed more apically, there is a lag in the evolution of filter-feeding traits. These results underscore the importance of resolving the phylogenetic relationships of toothed mysticetes and utility of a formal approach to inferring the feeding of extinct taxa.

**Funding Sources** This research was supported by the National Science Foundation (NSF EAR-1349607 to J.H.G. and B.L.B.).

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Technical Session 18: Synapsids (Saturday, October 21, 2023, 8:00 AM)

### A NEW NON-STAHLECKERIID KANNEMEYERIIFORM DICYNODONT FROM THE MANDA BEDS OF TANZANIA ASSOCIATED WITH STRONGLY CURVED CLAWS PROVIDES INSIGHT INTO NICHE PARTITIONING AMONG DICYNODONTS AND BIOTIC INTERCHANGE BETWEEN SOUTHERN AFRICA AND SOUTH AMERICA DURING THE MIDDLE TRIASSIC

George, Hady[1], Larkin, Nigel[2]

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The Manda Beds of Tanzania have produced a diverse assemblage of Middle Triassic tetrapods including 6 kannemeyeriiform dicynodont taxa. Here, we describe a seventh taxon from the Manda Beds based on a cranium and mandible. The presence of large tusks distinguishes it from *Sangusaurus* and *Angonisaurus,* a skull triangular in dorsal view distinguishes it from *Tetragonias*, the lack of a median snout ridge along the nasals distinguishes it from *Kannemeyeria* and *Rechnisaurus,* and a snout with a squared off tip distinguishes it from *Dolichuranus*. Unique features are identified in this new taxon including a large and boss-like posterior median ridge on the palatal surface of the premaxilla, and a substantially short preorbital region relative to the width of the palate and skull length. Additionally, it has partially unfused splenials and a slight median ridge along the anterior surface of the premaxilla. Surprisingly, this new taxon shares numerous features with the South American *Dinodontosaurus* such as a blunt snout, a preparietal, large tusks, a pronounced ventral curvature to the mandibular symphysis, and jaw rami strongly bent laterally. However, diagnostic features of *Dinodontosaurus* including tab-like anterior processes of the frontals and elongate suborbital processes of the postorbitals cannot be identified due to the quality of preservation of the material. A phylogenetic analysis recovers this taxon as the sister to *Dinodontosaurus*, and the clade they form is the sister to the *Angonisaurus* +

Stahleckeriidae clade. However, jackknife resampling and Bremer supports reveal weak support for these results, indicating this new taxon is unlikely to be a species of *Dinodontosaurus*. The likely close relation between this new taxon and *Dinodontosaurus* adds to the evidence for extensive biotic interchange between South America and Southern Africa during the Triassic. Moreover, the material was associated with dicynodont postcranial elements which vary in size and morphology, suggesting the material was part of a death assemblage of multiple taxa. While study of all the associated postcrania is beyond the scope of this project, we identify strongly curved manual unguals unlike those of any known dicynodont. This specialization might be related to niche partitioning among the dicynodonts of the Manda Beds as they may have granted either this new taxon or another, depending on which they belonged to, a greater capacity for shearing vegetation.

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Virtual Posters

**TRIVIA GAME AS A TOOL FOR TEACHING EVOLUTION, PALEONTOLOGY AND THE HISTORY OF LIFE TO UNDERGRADUATE STUDENTS**

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Teaching the contents of Earth’s life history in only a few lecture hours is quite challenging. Traditional teaching methods can be demanding, and are not well received by students, leading to a poor teacher-student relationship. The use of games can help students learn and remember contents, but converting a traditional lesson into a game is not an easy task, considering that all facts, jargon, and terminology must be adapted to provide appropriate and applicable content. Here we used a trivia game in an undergraduate biology class about the history of life on Earth through geologic time to motivate students, increase interaction, and improve the quality of learning. First, we delivered a traditional two-hour lecture, so the students gained basic knowledge about the history of life, to be used in the trivia game in the next class. The game starts in the Cambrian and ends in the Pleistocene, and we included the five mass extinctions. Each Period has six questions, and the five biggest mass extinction events have 3 questions each, some multiple choice and some free response questions. We divided the 16 students into three groups. The game works like a traditional tabletop game, which means there are different game pieces, rules, and a die with six sides to roll. After rolling the dice, players can move the pieces only 1 or 2 times if they answer the question correctly. However, if they are at one of the five extinction events and answer the question incorrectly, they must move their pieces back twice. We conducted an anonymous survey to get students' background and impressions. The main results are: 100% of the students had not yet taken the paleontology course; 100% fully agree that the activity helped consolidate their knowledge; 80% agreed that the game was more efficient for their learning than the traditional lecture; 60% strongly agree and 30% agreed that the lecture delivered before the activity helped them answer the questions; 100% agreed that this activity should be used in future evolution courses. We conclude, therefore, that modifying traditional classes and introducing new activities, such as a trivia game, can be a very effective way of improving the teacher-student relationship, reinforcing the subject matter, and consolidating new ways of teaching formal science to the adult public.

**Funding Sources** FAPES

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Virtual Posters

**NEWLY DISCOVERED FISH FAUNA FROM THE UPPER TRIASSIC DOCKUM GROUP OF WESTERN TEXAS**

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The Upper Triassic Colorado City Formation, Dockum Group, of western Texas preserves an abundance of isolated fish remains in a geologic deposit representing ancient ephemeral ponds, streams, and floodplains. Fish remains are preserved from a specific site near Otis Chalk, Texas as disarticulated scales and skull bones, with a few examples exceptionally preserved in three-dimensions. Two described species of fishes from the order †Redfieldiiformes, †*Cionichthys greeni* Schaeffer, 1967 and †*Lasalichthys otischalkensis*

Gibson, 2018 are based on articulated, complete skulls and partial bodies. Herein we describe new, previously undocumented biodiversity of fish fauna from the Otis Chalk site, including a nearly complete skull preserved three-dimensionally, The skull includes a skull roof, preoperculum, maxilla and circumorbital series. Based on the shape of the skull bones, paths of sensory canals, and ornamentation, this skull does not belong to either described redfieldiiform taxa from the Dockum Group, and likely represents a new species of actinopterygian fish. We compare it to similar taxa from the Early Mesozoic and discuss its affinities.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**NEW PRIMATE FOSSILS ACROSS THE EARLY EOCENE CLIMATIC OPTIMUM OF THE WIND RIVER BASIN, WYOMING**

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Primates have been collected from lower Eocene deposits of the Wind River Basin (WRB) since Wortman's expeditions in the 1880s, and these efforts have produced numerous species of euprimates and plesiadapiforms over the past 140-plus years. From 2012-2023, we have collected fossil mammals in the WRB, visiting many of the classic localities described by previous authors as well as discovering new localities. Here we present an account of these new specimens collected from the Lysite and Lost Cabin members of the Wind River Formation. These beds span the warmest part of the Early Eocene Climatic Optimum (EECO), beginning in Wasatchian biozone Wa-7 and lasting into Bridgerian biozone Br-1a. We have identified at least six euprimate taxa, including two adapoids and four omomyoids. One large anaptomorphine omomyoid may represent a new taxon or perhaps the relatively rare genus *Gazinius*. At least four species of plesiadapiforms have been identified as well. While most of the newly discovered specimens represent previously documented taxa, some are notable for their completeness and preservation of rare or previously unknown anatomy, including a nearly complete dentary of *Shoshonius cooperi* preserving the canine through third molar and the first anterior upper dentition of *Microsyops scottianus*. Euprimates and plesiadapiforms remain consistent in overall abundance from Wa-6 to Br-1a. Notharctids and microsyopids are more common than omomyoids throughout this interval. Interestingly, euprimates and plesiadapiforms remain consistent in overall abundance through the late Wasatchian in the Big Horn Basin (BHB) as well, where notharctids and microsyopids are also more common than omomyoids. Curiously, *Shoshonius*, the most abundant omomyoid in the WRB, is absent in the BHB. Omomyoids increase as a percentage of the overall fauna and as a percentage of the primate fauna in the earliest Bridgerian (Br-1a) of the WRB. Within omomyoids, previous studies have broadly noted an increase in omomyine abundance relative to anaptomorphines beginning in Br-1a; however, omomyines are more abundant than anaptomorphines beginning in Wa-7 of the WRB. Furthermore, anaptomorphines notably increase in abundance from Wa-7 to Br-1a (but are still less common than omomyines), a pattern that has not been discussed previously and may be due to environmental differences and/or a different evolutionary response to the EECO in the WRB relative to other basins.

**Funding Sources** This study was funded by NSF EAR 2124864, NSF EAR 2124939, NSF EAR 2124757, NSF EAR 2124926, the PSC-CUNY Faculty Award program, and Hunter College.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**A PALEOPATHOLOGIC SURVEY OF A *DIPLODOCUS SP.* (SAUROPODA: DIPLODOCIDAE) POPULATION FROM THE MORRISON FORMATION (KIMMERIDGIAN) OF MONTANA, USA**

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Although individual paleopathologies are important for understanding physiologies and behaviors of extinct taxa, paleoepidemiology, the study of disease

in prehistoric populations, provides greater context for the overall health of communities. One site for such study is the Mother's Day Quarry (MDQ), a monodominant bonebed of juvenile and sub-adult *Diplodocus sp.* in the Salt Wash Member of the Upper Morrison Formation, Bighorn Basin, Montana. Thus far, paleopathological studies of single-species, non-avian dinosaur mass death assemblages have been isolated to theropods, ceratopsians, and hadrosaurs. This study presents the first paleoepidemiologic survey of a single sauropod population as well as that of an age-segregated group of non-avian dinosaurs, providing insights into taxonomic and ontogenetic patterns of disease.

Individual skeletal elements were examined to identify patterns of pathologies within this single group. The minimum number of individuals (MNI = 16) was determined from previous work by the Museum of the Rockies (MOR) and the Cincinnati Museum Center (CMC) using the number of first right metatarsals. Identification of the average ontogenetic stage (juvenile to sub-adult) was assessed through histology of ribs from the site. Most of the remains are disarticulated, preventing correlation of pathologies to certain individuals; however, because the site represents a temporally and spatially secluded population, the overall prevalence of disease and injury could be documented.

Pathologies were identified on nine elements from at least two individuals. These include two fractured distal caudal vertebrae with healed calli, a left metatarsal V with bony spurs of idiopathic origin, three occurrences of two co-ossified caudal vertebrae, and a proximal caudal vertebra with a congenital abnormality in which two neural spines are present on a single neural arch. Evidence of infection with potentially associated trauma was also observed on a humerus and radius. Both elements have a cauliflower-like texture on the diaphysis that is most likely due osteomyelitis. Statistical analyses reveal that pathologies appear disproportionately within caudal vertebrae. Of particular note are the three co-ossified caudal vertebrae. Caudal fusion has been commonly observed in sauropods, especially diplodocids. The MDQ shows that this fusion occurred as early as the juvenile to sub-adult age, suggesting a possible ontogenetic etiology.

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Technical Session 20: Marine Mammals & Bats (Saturday, October 21, 2023, 1:45 PM)

**NEW JUVENILE BASILOSAURID WHALE MATERIALS FROM THE LATE EOCENE OF EGYPT PROVIDE CLUES ON DEVELOPMENTAL PATTERNS IN STEM CETACEA**

Gohar, Abdullah S.[1], Antar, Mohamed S.[2], El-Sayed, Sanaa[3], Sallam, Hesham M.[4]

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Basilosauridae represents a key lineage of early whales that played a pivotal role in the transition from semi-aquatic to fully aquatic lifestyles. Despite the rarity of basilosaurid juveniles in the fossil record, they are important sources for research on the growth and development of early whales, offering critical insights into the ontogeny and life history of these intriguing marine animals. Here, we report on two new juvenile basilosaurids (WH22-01 and QU19-01) from the late Eocene of the Fayum Depression in Egypt. WH22-01 represents a partial skeleton of a juvenile *Dorudon atrox*. It was discovered in Wadi El-Hitan from the Birket Qarun Formation, consisting of a partial skull, mandibles, numerous vertebrae, ribs, and scapulae. QU19-01 is a relatively smaller basilosaurid represented by a juvenile partial skull and auditory bulla. It was discovered in relatively younger deposits a few kilometers northeast of Wadi El-Hitan. Based on the skull size, tooth configuration, and periotic features of QU19-01, they are similar to those reported for *Saghacetus*. WH22-01 is classified as being in stage 7 of the 13 age classes for *Dorudon* and still has its third premolar erupting, while QU19-01 is either in or near stage 8 of ontogeny based on erupting the second premolar. WH22-01 is the first known *Dorudon* specimen at that ontogenetic level, providing a unique opportunity to expand our understanding of *Dorudon* ontogeny. The tympano-periotic complex in QU19-01 is large relative to the size of the skull, approaching proportions seen in adult *Saghacetus*, suggesting that hearing in these juveniles may have been well-developed at a young age, as seen in living cetaceans. The discovery of these two juvenile basilosaurids not only provides valuable insights into the growth and development of early whales but also confirms the significance of the

Fayum region as one of the important calving grounds for these marine mammals during the Eocene. Furthermore, the new finding supports previous hypotheses that suggest the Fayum region played a crucial role in the evolution and diversification of early whales.

**Funding Sources** Mansoura University, American University in Cairo, Science and Technology Development Fund (STDF).

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2019-2022 Jon C. Graff Awardees

**FROZEN IN TIME: UNIQUELY PRESERVED PROTOCETID WHALE ENTOMBED INSIDE DECORATIVE LIMESTONE FROM THE MIDDLE EOCENE OF EGYPT**

Gohar, Abdullah S.[1], Antar, Mohamed S.[2], El-Sayed, Sanaa[1], Sallam, Hesham M.[1]

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A massive block of decorative limestone destined for countertops or sidewalks was cut in a stonecutting yard in Shaq El-Thoaban (Cairo, Egypt), and it was discovered to be riddled with what appeared to be fossilized bones. The limestone block had already been cut into five thick slabs about 4.5 cm thick, and each saw cut removed 3.3 mm of limestone between adjacent plates, inadvertently creating an almost perfect cross-section of what has been identified as a protocetid whale. Protocetidae is a group of extinct whales that fall in the middle of the evolutionary transition of whales from land to sea. Investigation indicates that the block came from Gebel Hof Formation, of Bartonian late middle Eocene age (ca. 42 Ma), north of Khashm el-Raqaba in Wadi Tarfa, Eastern Desert of Egypt, the same locality that had produced the protocetid *Aegyptocetus tarfa*. The new specimen (MUVP 502) is an associated partial skeleton represented by a complete cranium, dentaries, many vertebrae, a humerus, an ulna, several ribs, and other unidentified elements. Unique preservation allows the examination of some internal anatomical features of the skull along with its external morphology. The hallmark characters that distinguish MUVP 502 from other protocetids include a large skull, measuring over 92 cm, larger than any previously described protocetid; large and robust premolars and molars, larger than any previously described African protocetid; short and fused mandibular symphysis, ending just after the posterior margin of the canine; thinning of the lateral walls of the mandibles; and enlarged mandibular canals. Comparison with related taxa suggests that MUVP 502 represents one of the largest protocetid whales on record. This size may have allowed MUVP 502 to hunt larger prey within its environment and therefore shifts its role in the ecosystem to that of a semi-aquatic apex predator. In addition to shedding light on a unique taphonomic window, this specimen also delivers an exceptional opportunity for a thorough morphometric assessment over time of morphological trends in earlier cetaceans.

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Technical Session 11: Archosaurs (Friday, October 20, 2023, 8:00 AM)

**COMPARISON OF CRANIAL AND POSTCRANIAL ONTOGENY IN A SIZE SERIES OF '*REDONDASAURUS*' (ARCHOSAURIFORMES: PHYTOSAURIA)**

Goldsmith, Erika R., Nesbitt, Sterling J., Stocker, Michelle R.

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The fossil record is rarely composed of complete, associated skeletons representing a whole ontogenetic series, making many paleobiological hypotheses pertaining to development and systematics difficult to test. Investigating the ontogeny of extinct reptiles becomes equally difficult because skeletal indicators of growth are not consistent across a skeleton. Therefore, data comparing the timing of cranial and postcranial growth may create a more complete framework to address paleobiology within an ontogenetic context. Phytosaurs (large archosauriforms that externally resemble extant crocodylians) have a wide range of skull shapes that have driven debates on their systematics and ecology; however, how ontogeny may be influencing these data is still unknown. To clarify the relationship between skull anatomy and ontogeny in phytosaurs, we assess the cranial (n=11) and associated postcranial ontogeny (n=3) of a size series (skull lengths [SL] ≈ 200 [25%] to 1200 [100%] mm) of '*Redondasaurus*' *bermani* (*Coelophysis* Quarry, Ghost Ranch, NM) and '*R.*' *gregorii* (Quay Co., NM). Femoral osteohistology of CMNH 51002 shows three highly vascular zones of woven and

parallel-fibered bone capped by two annuli and lines of arrested growth (LAGs). At this ontogenetic stage, neurocentral sutures are open and premaxillary alveoli are widely spaced, though not as widely spaced as observed in NMMNH P-44920 (SL≈25%). Femoral measurements of AMNH FR 32182 (SL≈30%) are similar to those of CMNH 51002 and may imply similar ontogenetic stages, suggesting the smallest and most rapidly growing '*Redondasaurus*' individuals have yet to fully hide their supratemporal fenestra in dorsal view with medially widened postorbital-squamosal bars. Osteoderm histology of CMNH 51002 agrees with the number of growth marks in femoral histology, preserving two LAGs within a highly vascular woven fibered bone matrix. Osteoderm histology associated with one of the largest skulls (YPM 3300; SL≈98%) reveals eight–ten LAGs, implying that large sizes (SL>100 cm) are attained during active growth stages. This study is the first to compare cranial and postcranial ontogeny within a single phytosaur taxon and shows that the largest phytosaur skulls represent actively growing individuals, suggesting large sizes do not equate to skeletal maturity in extinct reptiles. We highlight the importance of establishing a framework correlating cranial and postcranial ontogeny to interpret the paleobiology of extinct taxa.

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Colbert Poster Prize Session

### TO SEA OR NOT TO SEA: DIETARY ECOLOGY OF *ENHYDRITHERIUM TERRAENOVAE* AS INFERRED FROM DENTAL MICROWEAR TEXTURE ANALYSIS

Gomez, Isabella M.[1], Wang, Xiyu[1], Johnson, Solathus[1], Rogers, Ashley[1], Hulbert, Richard[2], DeSantis, Larisa[1]

[1]Department of Biological Sciences, Vanderbilt University, Nashville, Tennessee, United States, [2]Florida Museum of Natural History, Gainesville, Florida, United States

The extinct giant otter *Enhydritherium terraenovae* is thought to be related to both the extinct *Enhydriodon* and the extant sea otter *Enhydra*. While each of these taxa can be described as bunodont otters, where sheering is reduced in carnassials in favor of a crushing function—interpreting the paleoecology of *E. terraenovae* can be challenging. Prior to the discovery of specimen UF 100000 (University of Florida), *E. terraenovae* was only represented by very fragmentary fossils. However, since the discovery of UF 100000, interpretations of the paleoecology of *E. terraenovae* have expanded to include the use of forelimbs when swimming and the ability to spend significant time on land. Further, the discovery of *E. terraenovae* at sites further inland, implicates that *E. terraenovae* was not limited to only the sea. Here, we expand on the paleoecological interpretations of *E. terraenovae* by examining the dental microwear texture analysis of its teeth to determine if this taxon was durophagous like extant *Enhydra* or ate softer foods. Specifically, we compared the DMTA attribute values of complexity, anisotropy, textural fill volume, and heterogeneity of complexity (*HAsfc*, at two scales, 3x3 and 9x9) between extant *Enhydra* and the extinct *E. terraenovae*. DMTA attributes are largely similar between these taxa, indistinguishable in complexity (which is used to infer hard-food consumption), anisotropy (infers tough-food consumption), and textural fill volume (another metric largely correlated with hard-foods, particularly foods that leave deep features). *Asfc* mean values are also nearly identical, with mean values of 3.876 +/- 3.8 SD in *E. terraenovae* and 3.660 +/- 2.5 SD. These data are consistent with a diet that does contain hard-food. Thus, the ability to occupy inland terrestrial ecosystems does not necessarily negate the ability to be durophagous and instead may just broaden the foods consumed by *E. terraenovae.* Interestingly, *HAsfc*3x3 and *HAsfc*9x9 is significantly higher in *E. terraenovae* as compared to extant *Enhydra.* This suggests that extant *Enhydra* may be eating foods that leave a more homogeneous signal (due to the material properties of the food and/or grit accompanying the food). More work on extant otters is necessary to better understand the meaning of the difference in *HAsfc*3x3 and *HAsfc*9x9 between fossil and modern otters.

**Funding Sources** National Science Foundation and Vanderbilt University.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

### THE PRESENCE OF A NEW DREPANOSAUROMORPH CLAW MORPHOTYPE FROM THE CHINLE FORMATION

Goncalves, Gabriel S., Sidor, Christian A.

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Drepanosauromorpha is an extinct group of basal diapsid reptiles known from the Mid to Late Triassic (237–212 MA). The clade currently includes nine genera that are known from fossils collected in Europe, North America, and Asia. In recent years, new drepanosauromorph taxa have been described by their enlarged manual unguals from the Chinle Formation (e.g., *Ancistronychus paradoxus* and *Skybalonyx skapter*). Here, we suggest the presence of a new drepanosauromorph claw morphotype from the same site as *A. paradoxus* within the Chinle Formation in Petrified Forest National Park, Arizona based on a three-dimensionally preserved enlarged manual ungual. One feature this specimen shares with drepanosauromorphs that possess enlarged manual unguals is the presence of ventrally oriented lateral tuberosities on the flexor (ventral) surface of the claw. In addition, this specimen differs from all similar drepanosauromorph claw morphotypes/species with the articular cotyles oriented along the same plane as the flexor tubercle and the lateral tuberosities on the ventral surface. This specimen differs from *A. paradoxus* in particular by having the apex of the claw taper towards a point rather than a flat edge, the absence of a V-shaped cleft on the apex, the presence of lateral compression along the midline, having more robust flexor tuberosities, a more hemispherical flexor tubercle with a sharp delineation, the presence of a deep concavity between the flexor tuberosities and a proximodistally shortened articular end. This new Petrified Forest claw morphotype helps to demonstrate the amount of morphological variation that exists within similar drepanosauromorph species. The presence of this morphotype within the same site as *A. paradoxus* is suggestive of niche partitioning among *A. paradoxus* and this claw morphotype. Future work describing more drepanosauromorph material from the Chinle Formation and looking at the ecomorphological significance of these claws can help paint a clearer understanding of the ecological diversity of drepanosauromorphs.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

### MORPHOLOGY OF THE PETROSAL AND BONY LABYRINTH OF EXTINCT EQUIDAE (PERISSODACTYLA) AND PRELIMINARY PHYLOGENETIC ANALYSIS

Goodchild, Owen A.[1], Rosen, Sydney[2], Tissier, Jeremy[3], Meng, Jin[3]

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Perissodactyla, or odd-toed ungulates, is a clade of laurasiatherian placental mammals represented by 16 extant species of rhinos, tapirs, and horses. Perissodactyls were more diverse in the past, having a rich fossil record spanning from the Late Paleocene (~57 ma) to recent and including a myriad of extinct lineages. The relationships between the different families of perissodactyls remain poorly resolved, despite over a century of study. New morphological characters could thus potentially help to solve these issues. Recently, the petrosal and bony labyrinth have proven to be informative in the phylogenetic studies of other mammalian clades. The petrosal is the basicranial bone housing the inner ear, the organs of hearing and balance in mammals. Unlike those of artiodactyls, perissodactyl petrosals are poorly documented and have not been used to assess phylogenetic relationships. In this study, we used computed tomography to image and describe seven petrosals, six inner ears, and two stapes belonging to five European fossil equid taxa and six individuals. We used the 3D models to score these petrosals according to a published matrix from Spaulding et al. and described in detail by O'Leary and added nine additional characters from a published matrix by Mateus. Our results were encouraging, as while the topology is not a perfect match to what is expected from prior morphological work, it did recover important groupings that suggest the petrosal is phylogenetically informative in equids.

**Funding Sources** National Science Foundation Research Experience for Undergraduates at the American Museum of Natural History, Swiss National Science Foundation

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Preparators' Session (Thursday, October 19, 2023, 8:00 AM)

### ASSESSMENT OF JACKET TENSILE & FLEXURAL STRENGTH FOR SOME COMMON PLASTER JACKETING FABRICS

Gordon, Anthony E.

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Jacketing is a practice where, most commonly, a fossil and its surrounding matrix are encased with a plaster-soaked fabric and left to cure. While jackets play an important role in protecting fossils during transport and storage before reaching a laboratory setting, little published literature exists comparing the mechanical properties of jacketing materials. Burlap has been one of the most commonly used fabrics for making jackets, but recently, paleontologists have tried finding alternative fabrics; this study aimed to quantifiably compare some of the jacketing materials used in paleontology.

This study utilizes methods adapted from American Standards for Testing Materials to compare the maximum tensile and flexural strengths of plaster jackets made with veil fiberglass, polyester quilt batting, polyester fleece, 12-ounce burlap, and both parallel & diagonally orientated 10-ounce burlap. One-way ANOVA and follow-up pairwise comparisons showed that jackets made in similar dimensions and with the same number of layers but with different fabrics had maximum tensile values that were all significantly different. In the tests for flexural testing, the maximum flexural values for comparisons between diagonally orientated 10-ounce burlap and veil fiberglass, as well as polyester quilt batting and polyester fleece reporting as statistically similar in pairwise comparisons.

The mean peak tensile load values from testing samples were recorded in pounds of force and from highest to lowest were 12-ounce burlap (600.84 lbf), parallel orientated 10-ounce burlap (582.41 lbf), polyester fleece (460.95 lbf), diagonally orientated 10-ounce burlap (349.27 lbf), polyester quilt batting (220.69 lbf), and veil fiberglass (70.80 lbf). From highest to lowest, mean peak flexural load values were polyester fleece (31.91 lbf), polyester quilt batting (30.15 lbf), 12-ounce burlap (23.39 lbf), parallel orientated 10-ounce burlap (13.56 lbf), diagonally orientated 10-ounce burlap (6.60 lbf), and veil fiberglass (2.66 lbf). These results provide useful insights when deciding what materials to use to make plaster jackets. Materials that make jackets with higher flexural strengths should be more appropriate when making jackets for larger fossil specimens. Polyester fleece may be a new, useful field jacketing material as it provides the greatest flexural strength of the materials tested and provides greater tensile strength in any orientation than burlap provides in its diagonal orientation.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**RE-EVALUATION OF THE GIGANTIC TITANOSAURIAN SAUROPOD DINOSAUR *PARALITITAN STROMERI* FROM THE MID-CRETACEOUS BAHARIYA FORMATION OF EGYPT AND ITS PHYLOGENETIC RELATIONSHIPS TO OTHER EXCEPTIONALLY LARGE TITANOSAURS**

Gorscak, Eric[1], Lamanna, Matthew[2], Salem, Belal S.[3], El-Sayed, Sanaa[3], Sallam, Hesham M.[4]

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In 2001, the giant titanosaurian sauropod dinosaur *Paralititan stromeri* was described from the mid-Cretaceous (Cenomanian) Bahariya Formation of Egypt. Despite the incompleteness of the holotype (Egyptian Geological Museum [CGM] 81119), the 1.69 m humerus of *Paralititan* indicated the presence of an extraordinarily large-bodied titanosaurian on the African continent, rivaling in size those known from the Americas at the time (e.g., *Argentinosaurus*, *Alamosaurus*). Since then, several enormous new titanosaurians have been described from the mid–Late Cretaceous of South America (e.g., *Dreadnoughtus*, *Futalognkosaurus*, *Notocolossus*, *Patagotitan*), as have several other African Late Cretaceous titanosaurs (e.g., *Mansourasaurus*, *Rukwatitan*). Following from these discoveries, recent analyses have proposed the existence of certain clades of often gigantic titanosaurians (e.g., Colossosauria, Lognkosauria). *Paralititan*, however, has been omitted from these analyses, most likely due to its fragmentary nature and the brevity of its published description.

Here we provide an updated assessment of the evolutionary relationships of *Paralititan* to test whether this taxon belongs to one of the aforementioned clades of exceptionally large titanosaurs. We re-evaluated and updated the scorings of *Paralititan* in our working phylogenetic dataset and conducted both parsimony and tip-dating Bayesian phylogenetic analyses (57 taxa scored for 285 variable and 302 autapomorphic characters). Our parsimony results postulate *Paralititan* as the sister taxon of *Rukwatitan*, with this African clade being the outgroup to a clade of generally large titanosaurs that consist mainly of forms widely regarded as lognkosaurians plus a clade of taxa with a biconvex first caudal vertebra (e.g., *Alamosaurus*, *Dreadnoughtus*). The tip-dating Bayesian analysis produced similar results, except that *Rukwatitan* was recovered within Lognkosauria, with *Patagotitan* and *Paralititan* being successive outgroups to this clade. Furthermore, the Late Cretaceous ingroup clade to the exclusion of *Paralititan* consists of the small-bodied Saltasauridae and several small–medium-sized titanosaurians from Afro-Eurasia (e.g., *Mansourasaurus*) amongst Colossosauria and the 'biconvex first caudal clade.' The latter results support the notion that, on continental Africa, multiple titanosaurian lineages underwent trends toward either larger or smaller body sizes, paralleling a pattern seen in the Late Cretaceous of South America.

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Technical Session 14: Crocodylomorphs & Turtles (Friday, October 20, 2023, 1:45 PM)

**THE FUNCTIONAL RELATIONSHIP BETWEEN AXIAL SKELETON MORPHOLOGY AND PLEURAL DISPLACEMENT IN THE AMERICAN ALLIGATOR (*ALLIGATOR MISSISSIPPIENSIS)*: VALIDATING AN OSTEOLOGICAL CORRELATE FOR THE HEPATIC PISTON IN CROCODYLOMORPHA**

Grand Pre, Clinton A.[1], Thielicke, William[2], Diaz, Raul[3], Hedrick, Brandon P.[4], Elsey, Ruth M.[5], Schachner, Emma R.[6]

[1]Cell Bio and Anatomy, Louisiana State University Health Sciences Center, New Orleans, Louisiana, United States, [2]OPTOLUTION, Loerrach, Germany, [3]Biological Sciences, University of California, Los Angeles, California, United States, [4]Biomedical Sciences, Cornell University, Itaca, New York, United States, [5]Louisiana Dept. of Wildlife and Fisheries, Grand Chenier, Louisiana, United States, [6]Physiological Sciences, University of Florida, Gainesville, Florida, United States

In Aves, there is an established functional anatomical relationship where forked thoracic ribs and distinct articular processes on the thoracic vertebrae create a furrowed thoracic ceiling and incise the dorsal surface of the gas-exchanging lung keeping it immobilized. These osteological correlates have been used extensively to reconstruct the lungs of non-avian dinosaurs. However, crocodilian-line archosaurs evolved a novel respiratory mechanism called the hepatic piston apparatus, and the evolutionary history of this specialized respiratory anatomy remains ambiguous. Axial skeletal osteological correlates found in extant crocodilians have previously been proposed in association with the hepatic piston. They are: A) a parapophysis that migrates from the centrum to the transverse process after thoracic vertebra three (T3); B) broad, flat transverse processes that progressively elongate to the caudalmost thoracic vertebra (T11); C) a lack of forked ribs after T3; and D) a rib-free lumbar region. We functionally validate these specific osteological correlates in an extant crocodilian, *Alligator mississippiensis*, to assess whether these correlates may be used to reconstruct the origin and timing of this mechanism in extinct pseudosuchian archosaurs. We recorded ultrasound video of the lung pleura, liver, and viscera sliding craniocaudally in seven individuals of *A. mississippiensis*. Data were collected at four anatomical locations: in the axilla, mid-thoracic, pleural/hepatic boundary, and a post-hepatic position for a total of 170 videos. The ultrasound recordings show that in every instance, the pleura slides across the smooth thoracic ceiling during ventilation. Quantitative measures of displacement were calculated at the hepatic margin position using the liver as a strongly visible anatomical landmark. The displacement was measured as the distance between the cranialmost and caudalmost position of the liver during relaxed respiration. Displacement was reported as a percentage of the snout-vent length (SVL) for each animal and ranged between 2.19% and 15.78% SVL. These data confirm that even at rest there is a functional relationship between pleural sliding and the morphology of the axial skeleton, which can be used to determine when this respiratory morphology evolved in extinct pseudosuchian archosaurs.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**GLIDING BETWEEN CONTINENTS: THE RECORD OF THE FLYING SQUIRREL *MIOPETAURISTA* (SCIURIDAE, RODENTIA) IN NORTH AMERICA**

Grau-Camats, Montserrat[1], Casanovas-Vilar, Isaac[1], Crowe, Cheyenne J.[2], Samuels, Joshua X.[2]

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Even though flying squirrels (Rodentia, Sciuridae, Sciurinae, Petromyini) are currently only represented by the genus *Glaucomys* in North America, their fossil record provides evidence for a much longer history in this continent. Indeed, the purported oldest flying squirrels (known only from dental remains) date back to the late Eocene of Wyoming, and although this group was never as diverse as in Eurasia, several different genera are known from the Oligocene to the beginning of the Late Miocene. After the extinction of the genus *Petauristodon* at the end of the Clarendonian (ca. 9 Ma) flying squirrels are not recorded in North America by about 3 million years until the latest Miocene/Early Pliocene, when they are represented by the genus *Miopetaurista.* This large-sized Eurasian genus was particularly successful and widespread. In Eurasia, up to ten different species are known ranging from the early Miocene to the Pliocene, and from Portugal to China. Recent studies based on very complete remains, have identified *Miopetaurista* as sister taxon to the extant giant flying squirrel (*Petaurista*), with a remarkably similar postcranial skeleton. North American occurrences are exclusively restricted to Florida (USA), and only two specimens are known there: one from the early Pleistocene Haile 15A locality; and other from the early Pliocene Palmetto Fauna. Both specimens have been assigned to an endemic American species, *Miopetaurista webbi*. Recently, the early Pliocene (latest Hemphillian or early Blancan) Gray Fossil Site in Tennessee (USA) yielded another specimen (ETMNH 34820), an isolated lower third molar, which expands the known range of this genus. Its size matches that of *M. webbi*, but it shows a somewhat simpler trigonid basin, with lower and less developed transverse ridges. It is also similar in size to *Miopetaurista thaleri*, the only known Pliocene European species, but differs in its better-developed anterosinusid and simpler trigonid basin. The dispersal of *Miopetaurista* from Eurasia into North America is framed within a major late Neogene faunal dispersal that included other rodents (*Castor, Eutamias*), talpids (*Neurotrichus*, *Parascalops*), soricids (*Paenelimnoecus*, *Crusafontina*), the meline *Arctomeles*, and an ailurine (*Pristinailurus*), which also occur at the Gray Fossil Site. Occurrences of some Eurasian taxa at the Gray Fossil Site and the high arctic of Canada, but not western North America, point to high latitude dispersals.

**Funding Sources** R+D+I project PID2020-117289GB-I00 (MCIN/AEI/10.13039/501100011033/), G. de Catalunya/CERCA Programme, AGAUR (2001 SGR 00620) and NSF Grant #0958985.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**TESTING MORPHOLOGICAL CORRELATES TO ECOLOGICAL SPECIALIZATIONS IN SQUAMATES: INNER EAR SIZE ADAPTATIONS TO DIFFERENT HABITATS**

Greaves, Minnie F.

Zoology, University of Cambridge, London, United Kingdom

Understanding the relationship between form and function is essential for understanding adaptations. Inner ear adaptations have been intensely studied, specifically the shape and size of the semi-circular canals. However, less attention has been given to the size of the inner ear and its morphological correlates and its resulting effects on the anatomy of the braincase. In order to determine morphological correlates to inner ear size I took a series of linear measurements of representative squamate taxa by measuring the size and shape of the intercranial space between the ears. Principal component analysis revealed strong correlation between intercranial size and habitat, and no correlation with either body form or body size. Results were still significant even when corrected for phylogenetic relationships. When fossil specimens were included in the analysis, it showed which habitat correlated with their inner ear size. For example, *Diablophis* inner ear size was representative of a fossorial habitat, indicating it could have been that fossil species' lifestyle. Our results overall demonstrate that inner ear size variation among squamates can be explained by habitat differences and can shed a light on ancient species' habitats.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**DENTAL MESOWEAR AND HYPSODONTY INDEX FROM TUGEN HILLS SUCCESSION**

**BOVIDAE DEMONSTRATE RELIANCE ON MIXED-FEEDING AND INCORPORATION OF ABRASIVE DIETARY MATERIAL FROM LATE MIOCENE INTO PLIO-PLESITOCENE**

Greiner, Elliot, Orlikoff, Emily, El-Shaarawi, Wesam, Sherwood, Rowan

Anthropology, University of Michigan, Ann Arbor, Michigan, United States

The Tugen Hills Succession (THS) of the Baringo Basin (Kenya) is a nearly continuous geologic succession spanning from the Middle Miocene (~15.5 Ma) to the Late Pleistocene (~240 Ka) that includes one of the largest concentrations of hominoids from 14 to 4 Ma. Paleoecological data from this succession are highly relevant to determining the nature and mode of environmental change during ape and human evolution, and while much work has characterized these environments in the Plio-Pleistocene, less has been done for those from the Miocene and early Pliocene.

This study offers the first mesowear dataset for the Tugen Hills Succession and is one of the largest focused specifically on Miocene/Plio-Pleistocene bovids in eastern Africa. These data reflect the general increase in the diversity of post-Miocene bovid diets in the THS, and while they can in some cases be extrapolated to describe an 'opening' of environments after the late Miocene, the enigmatic influence of spatial and temporal scale, combined with caprice of mammalian feeding habits—particularly as they relate to seasonality— limit assemblage-level claims of paleoenvironment. The diversification of mesowear scores in the Plio-Pleistocene data conforms with other datasets in that an expansion of arid and/or grassland environments occurred after the late Miocene, however mesowear values suggest the predisposition of THS bovids to mixed feeding. Evidence also exists for niche partitioning between some tribes, particularly among the hyper-grazing Alcelaphini and more browsing dominated Tragelaphini, with fossil Aepycerotini, Alcelaphini, Antilopini, Bovini, and Cephalophini maintaining similar values to their modern counterparts. These patterns are generally supported by bovid $\delta^{13}$C values from the late Cenozoic of eastern and southern Africa, and further highlight the influence of heterogeneous environments on the Plio-Pleistocene African landscape.

**Funding Sources** National Science Foundation; Leakey Foundation

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Technical Session 7: Birds (Thursday, October 19, 2023, 8:00 AM)

**THE DEVELOPMENTAL MECHANISMS UNDERLYING THE EVOLUTION OF THE AVIAN PELVIS FROM THE ANCESTRAL ARCHOSAURIAN CONDITION**

Griffin, Christopher, Morris, Zachary S., Bhullar, Bhart-Anjan S.

Yale University, New Haven, Connecticut, United States

The stepwise evolution of the highly derived avian pelvis is well-documented by an excellent fossil record. This transition is paralleled during the early ontogeny of living birds, with embryonic pelves initially possessing ancestral anatomical features (e.g., anteroposteriorly short ilium, anteriorly directed pubis, pubic ‘boot’) found among non-avian archosaurs, which transform into derived conditions across roughly two days of *in ovo* development. The transient presence of these early archosaurian and stem bird pelvic features reveals such ancestral forms are not completely lost to time and enables detailed investigation of the developmental mechanisms underlying a major anatomical transition. Previous developmental studies have shown that genes such as PAX1, EMX2, and IHH that regulate bone development and cellular proliferation are expressed in the hip during this critical developmental window. To investigate the role these genes may have played in generating the apomorphic avian pelvis, we developed a method to capture three-dimensional (3D) gene expression patterns via fluorescent *in situ* hybridization in combination with immunofluorescence assays for skeletal precursors in embryos made optically transparent via a modified CLARITY protocol. High-resolution confocal microscopy and three-dimensional (3D) geometric morphometrics allows us to not only quantitatively compare the shape of gene expression patterns to the embryonic pelvic morphology of birds and crocodylians (through, e.g., allometric trajectory analyses), but also reconstruct hypothesized gene expression patterns which produced similar morphologies in stem birds. Data from 3D documentation of cell cycle processes (cellular proliferation, apoptosis) across the developing pelvis also contribute to this goal. Our next steps will be to artificially down- or up-regulate these key genes and cellular processes, during avian pelvic development using microbead implantations. We have previously hypothesized that the retention of these states is the result of overall covariation among seemingly disparate portions of the archosaurian pelvis. This hypothesis can be tested via these targeted embryonic experiments: inducing these developmental processes early in ontogeny should produce a bird with a hyper-elongated ilium and extremely retroverted pubis, whereas arresting these developmental processes should result in the retention of ancestral states into late ontogeny.

**Funding Sources** NSF PRFB-2010677, NSF EAR-PF-195288, NSF CAREER-2046868

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Preparators' Session (Thursday, October 19, 2023, 8:00 AM)

**ENHANCED RESOLUTION AT THE MECHANICAL-DIGITAL INTERFACE: A METHODOLOGY TO ASSIST IN PREPARATION DECISION MAKING AND IMPROVED RESEARCH AND OUTREACH OUTCOMES**

Groenke, Joseph, O'Connor, Patrick M.

Ohio University, Athens, Ohio, United States

Fossil preparation finds technical means to balance specimen preservation with the development of data to address research questions. This conservation-development tension is most evident when in-matrix associations and data preserved at burial/collection are weighed against matrix-free, disassociated, and repaired fossils. Decisions rest at the interface of taphonomy, field collection, digital preparation, and mechanical preparation. Molding and casting, and more recently a host of scanning modalities, are typically employed to capture bone/matrix relationships that can then facilitate or obviate further mechanical preparation.

Methodological advancements presented here will provide mechanical and digital preparators with approaches to aid in this decision-making process, and in some cases, to pursue both in-situ and in-life outcomes. Capture of spatial relationships between fragments or elements (whether CT, surface scanning, or photogrammetry) is requisite, even if the resolution provided is inadequate for detailed morphological study. This may occur either at the field site or in the lab. For complex, multi-specimen or -element collections such as jackets from microvertebrate bone beds or associated skeletons, a coarse initial CT scan in which rough morphology is captured can serve as a volumetric scaffold. Mechanically-extracted fossils can be scanned at the desired resolution for morphological study or other purposes, and then mapped back into the coarsely-resolved coordinate space created in the first step. Applications include explicit spatial re-association of specimens collected in multiple jackets, capture of fossil/matrix dynamics, and quarry mapping with basic morphology integrated into an accurate 3D representation of burial conditions across a large area/volume. This can simplify decision-making for mechanical development in circumstances where the research value of spatial relationships is currently ambiguous. The methodology also optimizes the use of “old” or “bad” scan data. Unification into a single, model frame space of multiple scanning events and derivative segmentation products allows for expedited digital preparation when better scan data or segmentations become available. Scan events can be treated as time series for potential 4D analysis of process, and a unified frame space of CT scan events allows complex queries and filtering possibilities for otherwise poorly resolved or radiographically dense materials.

**Funding Sources** Ohio University Heritage College of Osteopathic Medicine; NSF EAR_1525915

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Symposium Session: Theropod Flight Origins (Thursday, October 19, 2023, 1:45 PM)

**NEW INFORMATION ON THE SOFT TISSUES AND BONE ANATOMY OF THE FOREWINGS CONSTRAINS THE POWERED FLIGHT PERFORMANCE OF *MICRORAPTOR* (THEROPODA: DROMAEOSAURIDAE)**

Grosmougin, Maxime[1], Kaye, Thomas G.[2], Chotard, Matthieu[1], Barlow, Luke A.[1], Wang, Xiaoli[3], Zheng, Xiaoting[4], Pittman, Michael[1]

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*Microraptor* was described for the first time 23 year ago. Since then, numerous studies have investigated this four-winged dinosaur, but there is not yet consensus on its flight performance and lifestyle.

Previous reconstructions of the forewing were based on two specimens: IVPP V13352 and BMNHC PH881; with observations and descriptions of primary, secondary and a couple of covert feathers, leaving the rest of the feathering of the wing subjective. Laser-Stimulated Fluorescence (LSF) of existing *Microraptor* specimens, but also 12 new specimens triaged from ~100 in the Shandong Tianyu Museum (STM), reveals otherwise hidden feather, skin and muscular details that refine wing shape, feather layering and provides new information about the forelimb structure. The elongated and recurved primary remiges of the forewing give the wing tip a slender V shape, as seen in modern birds with a high-speed wing shape (e.g., falcons and swallows). The newly described major coverts of the forewing display a 'short primary covert and long secondary covert' pattern that appears to be unique to *Microraptor*. Skeletal features of the forelimb remain mostly unchanged from previous descriptions, but we bring new information on previously described elements. For example, the prominent tuberosity of the radius indicating the presence of a strong *biceps brachii* is potentially linked to the development of a strong flexor/stabilizer group as seen in modern Falconiformes that stoop down to catch prey, congruent with *Microraptor*'s pedal soft tissue morphology and it's the high-speed wing shape. With the new information recovered in preserved soft tissues, including those of the shoulder, propatagium and postpatagium, we can better understand the relationship between *Microraptor*'s feathering and its underlying forelimb. *Microraptor* possessed features that helped to stiffen the wing and keep its feathers cohesive during flight: presence of deeply imbedded calami in the postpatagium combined with the presence of a broad digit II, and the discovery of a third carpal between the ulna, semilunate and metacarpal III. Ultimately, our data supports an emerging picture that *Microraptor* had greater flight capabilities than previously assumed and was not a strict glider. Our data also suggests that *Microraptor* shared many common traits with modern birds, especially birds of prey, and potentially some of their hunting strategies.

**Funding Sources** RGC General Research Fund (17120920; 17105221)

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Technical Session 5: Ungulates (Wednesday, October 18, 2023, 1:45 PM)

## GIANT EXTINCT BOVIDS FROM THE PLEISTOCENE OF THE CENTRAL HIGHLANDS OF KENYA

Grossman, Aryeh[1], Waweru, Veronica[2], Malit, Nasser R.[3], munge, Stephen[4], Ndiritu, Francis[5], Omuombo, Christine[6], Kinyanjui, Rahab[4], Chege, Lorna[7], Kinyua, Richard[8], Kirera, Francis M.[9]

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The altitude and topography of high-elevation zones combine to modulate the effect of global climate particularly during harsher conditions, and also create diverse ecotones within a single region. Thus, such regions attract diverse types of animals as well as provide livable conditions during difficult times. Yet, in Africa paleontological sites in high-elevation regions are relatively unexplored. We recently initiated paleontological investigations of the Central Highlands of Kenya (CHK), a hitherto mostly ignored region. We recovered diverse vertebrate fossil assemblages from over 20 sites spanning the latest Miocene through the Anthropocene
. The different faunas include proboscideans, perissodactyls, carnivorans, cetartiodactyls, primates, and rodents. In many instances, the faunas are associated with hominin remains and stone tools. Bovids represent the most common animals in most of the sites. Among the bovid remains recovered in middle to late Pleistocene deposits we recovered fossils of two very large bovids. At the site of Karuchwa, we recovered a partial skull that includes a giant horncore. The shape of the basicranium and morphology of the horncore are consistent with *Syncerus* cf. *antiquus* rather than *Bos* (*Pelorovis*) *oldowayensis*. However, the horncore is larger than any *S. antiquus* reported to date. At Kinamba quarry, a site in the Abredare Range we recovered several teeth. Two of the teeth are consistent with *S.* cf. *antiquus*. A third tooth, a molar, is extremely large and more hypsodont than any other giant bovids and

is unlike *Syncerus* spp. Whether a new species or an extremely large individual of a different known taxon, it is clear that at least two giant bovids were present in the CHK. Finding different types of giant bovids at the same site is extremely rare. Giant bovids are typically associated with open habitats and extreme hypsodonty is usually associated with grazing behaviors. The giant bovids indicate that at least some of the ecotones in the CHK were relatively open habitats.

**Funding Sources** Funding was provided by the Wenner-Gren Foundation, and PAST.

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Technical Session 17: Afrotheria & Mammal Macroevolution (Saturday, October 21, 2023, 8:00 AM)

### SMALL MAMMALS IN A LARGE TREE: EXAMINING THE TIMING OF THE EARLY THERIAN RADIATION USING A NOVEL PHYLOGENETIC METATREE

Grossnickle, David[1], Hellert, Spencer[2], Ely, Ricardo[3], Slater, Graham[4], Lloyd, Graeme[5], Angielczyk, Kenneth D.[6], Bormet, Allison[1], Wilson Mantilla, Gregory[7]

[1]Oregon Institute of Technology, Klamath Falls, Oregon, United States, [2]Columbia College, Chicago, Illinois, United States, [3]Indiana University, Bloomington, Indiana, United States, [4]University of Chicago, Chicago, Illinois, United States, [5]Independent Researcher, Leeds, United Kingdom, [6]Field Museum of Natural History, Chicago, Illinois, United States, [7]University of Washington, Seattle, Washington, United States

Mammals achieved considerably greater ecological diversity in the Cenozoic compared to the Mesozoic. However, there remains uncertainty about the origins of this rise in diversity, such as whether it was triggered by novel ecological opportunities following the Cretaceous-Paleogene (K-Pg) mass extinction event 66 Ma. To test hypotheses on the timing of the mammalian radiation, studies commonly rely on analyses of fossil-only datasets, which often ignore the influence of phylogeny, or analyses of extant-only datasets, which struggle to recreate macroevolutionary patterns in deep time. Thus, an integrative approach is needed that incorporates paleontological data, neontological data, and phylogenetic comparative methods. To this end, we generated a time-calibrated meta-phylogeny ('metatree') comprising over 3000 species of technotherians (therians and close relatives) from the Mesozoic and Cenozoic, based on 115 published character matrices and a molecular phylogeny of extant mammals. To quantify ecomorphological patterns, we collected jaw lengths (as a proxy for size) and jaw measurements that correlate with diet for 430 extinct and extant species. We then fit a suite of evolutionary models to the data to test various hypotheses on the i) timing of the start of the therian radiation and ii) potential shift in mode of evolution. Although results are sensitive to time-calibration methods and phylogenetic uncertainty, they generally show evidence for a shift in mode of evolution prior to the K-Pg boundary. For both the jaw correlates of diet and body size analyses, results suggest a shift from a constrained (Ornstein-Uhlenbeck) or stochastic (Brownian motion) mode of evolution to an 'early burst' mode of evolution, with the best-fitting models being those that model this shift occurring between 76 and 66 Ma. These results suggest that the ecological diversification of therians began in the latest Cretaceous, prior to the K-Pg extinction event. However, our results are also congruent with the hypothesis that the therian radiation was a multiple-step process that involved bursts in diversification at multiple points in time, such as following both the Cretaceous Terrestrial Revolution (ca. 80 Ma) and the K-Pg extinction event. Further, we emphasize the importance of continued efforts to collect early mammal fossils and resolve relevant stratigraphic information, which will allow for more robust tests on the timing of the mammalian radiation.

**Funding Sources** NSF DEB-1754502, NSF DBI-1812126

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

### VERTEBRAL FUSION IN A COLUBRIFORM SNAKE FROM THE LATE OLIGOCENE RUKWA RIFT BASIN, SOUTHWESTERN TANZANIA

Grover, Tessa E.[1], Montalvo, Ariana D.[2], Roman, Kiara[2], McCartney, Jacob[2], Mtelela, Cassy[3], Roberts, Eric M.[4], Stevens, Nancy J.[5]

[1]Physical Therapy Department, Nazareth University, Rochester, New York, United States, [2]Biology Department, Nazareth University, Rochester, New York, United States, [3]Department of Geology,

University of Dar es Salaam, Dar es Salaam, Tanzania, United Republic of, [4]Earth and Environmental Science, James Cook University, Townsville, Queensland, Australia, [5]Department of Biomedical Sciences, Ohio University, Athens, Ohio, United States

The late Oligocene Nsungwe Formation in the Rukwa Rift Basin of Southwestern Tanzania has produced a diverse vertebrate fauna including species of fishes, lizards, turtles, and mammals. It also includes the largest known sub-Saharan snake fauna from the Paleogene, consisting of nine colubriform and constrictor snakes. Among the specimens of one of the colubriform morphotypes is a pair of fused anterior trunk vertebrae. The vertebrae are articulated such that they lie in a straight line. The specimen shows excess bone growth along the ventral and lateral aspects of the centra, causing fusion of the vertebrae around the cotyle-condyle joint. The cotyle of the anterior vertebra and the condyle of the posterior vertebra show no signs of fusion, indicating that the pathology was limited to this single joint. The hypapophysis of the anterior vertebra is deformed as a result of the excess growth. Only one of the two synapophyses adjacent to the fusion is intact, and it shows no signs of pathology. The zygosphene and zygapophyses were likewise unaffected. A microCT scan indicates that bone fusion is limited to outside the joint capsule of the cotylar-condylar joint, and that the joint surfaces are distinctly separated. Skeletal abnormalities can occur due to various illnesses, injuries or environmental factors. Vertebral fusions may result from congenital defects, trauma, arthritis (spondyloarthropathy), and non-pathological ossification of vertebral ligaments (diffuse idiopathic skeletal hyperostosis, or DISH). Apart from bony overgrowth, the vertebrae show typical morphology, allowing elimination of trauma and congenital defect as explanations for the observed morphology. Distinct separation of joint surfaces (i.e., lack of bridging) argues against a diagnosis of spondyloarthropathy and is consistent with DISH. Cause for fusion in this case is uncertain. Diagnosis of paleopathologies in extinct species is hampered by inconsistent use of terminologies, but regardless of cause, vertebral fusion impacts flexibility. The absence of abnormalities at the anterior and posterior ends of the specimen suggests either limited or discontinuous impacts for this individual.

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**REEXAMINING DIVERSIFICATION DYNAMICS OF THE PTEROSAURIA**

Guenther, Merrilee F., Dilollo, Isabella

Biology, Elmhurst University, Elmhurst, Illinois, United States

Constructing a picture of pterosaur diversity during the Mesozoic is complicated by the limitations of the fossil record for pterosaurs due to sampling and preservational biases. Concerns about pterosaur diversity being obscured by the availability of exceptional preservation in the fossil record constrains research about the evolution of the group.

A reexamination of the diversity of the Pterosauria was completed based on a dataset assembled using the Paleobiology Database, including 400 occurrences. The analysis supported the hypothesis that pterosaurs achieved their highest diversity during the Cretaceous. The increase in diversity is driven by the diversification of derived pterodactyloids, particularly the Azhdarchoidea and Pteranodontoidea.

To complement the analysis of pterosaur diversity an analysis of speciation and extinction dynamics was completed utilizing the same dataset. To compensate for uncertainty in the fossil record a Bayesian approach, utilizing the program PyRate, was used to determine how speciation and extinction rates for pterosaurs varied throughout the Mesozoic. Net diversification rates appear to increase and peak during the Early Cretaceous. The net increase corresponds to a decline in extinction rates during that time. In the Late Cretaceous, net diversification rates also seem to be relatively stable, with speciation rates showing a moderate increase and extinction rates showing a moderate decrease. Resolving pterosaur speciation and extinction dynamics can further deepen our understanding of the pterosaur faunal turnover that occurred between the Early and Late Cretaceous.

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Technical Session 14: Crocodylomorphs & Turtles (Friday, October 20, 2023, 1:45 PM)

**OSTEOHISTOLOGY OF A LARGE SAMPLE OF *ALLIGATOR MISSISSIPPIENSIS* PROVIDES A FOUNDATION FOR INTERPRETING GROWTH IN *ALLIGATOR* FROM THE EARLY PLIOCENE GRAY FOSSIL SITE**

Gunnin, Davis[1], Schubert, Blaine W.[1], N. Woodward, Holly[2]

[1]Geosciences, East Tennessee State University, Johnson City, Tennessee, United States, [2]Department of Anatomy and Cell Biology, Oklahoma State University, Tulsa, Oklahoma, United States

Meaningful interpretation of bone histology and extrapolation to interpret an extinct organism's life history requires an understanding of the factors influencing bone growth and histological presentation. Histological analysis of long bone thin sections is commonly used to infer growth rates and ecology in extinct vertebrates, particularly within Archosauria. As such, much of our knowledge of archosaurian paleohistology is derived from the two extant lineages: avian dinosaurs and crocodilians. However, few studies have used large samples of wild individuals to explore how different climate and habitat regimes affect histological presentation of growth rate and bone tissue. The American alligator (*Alligator mississippiensis*) is widely available for study in the United States and has been the subject of several osteohistological analyses. These used one or a few specimens and, in one study, a larger sample of pen-raised captive born specimens but no published works have incorporated large, geographically diverse samples. To fill this gap in our knowledge of archosaurian osteohistology we prepared and analyzed humeral and femoral thin sections from 45 *A. mississippiensis* from across their natural range. We compared counts and measurements of growth arrest lines (LAGs) with femoral length, the latter of which is strongly correlated with body size. Comparison of these data revealed that larger individuals subject to shorter growing seasons (i.e., those in cooler climates) tend to show more LAGs when compared to more southerly *Alligator* specimens of similar size. Comparing smaller individuals showed the inverse relationship, perhaps due to regional differences in population density or an ontogenetic shift in diet. Finally, histological thin sections of early Pliocene *Alligator* sp. fossils from the Gray Fossil Site (GFS), Washington Co., Tennessee were prepared to explore the paleobiology of this biogeographically unique Appalachian *Alligator*. Preliminary results show that the GFS *Alligator* grew more slowly than *A. mississippiensis* and may have reached reproductive maturity at a smaller size. Slower growth and earlier maturity in this taxon may mean that small adult size is a phyletic trait, similar to other *Alligator* species earlier in the Cenozoic. However, unfavorable conditions for *Alligator* at the GFS sinkhole pond could also account for slow growth and earlier maturity.

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Colbert Poster Prize Session

**HEARING ABILITIES AS DRIVERS OF EVOLUTION AND DIVERSIFICATION OF THE DELPHINIDA**

Guo, Zixuan[1], Kohno, Naoki[2]

[1]Graduate School of Science and Technology, University of Tsukuba, Tsukuba, Ibaraki, Japan, [2]National Museum of Nature and Science, Tokyo, Japan

Delphinoidea (i.e., Delphinidae, Monodontidae, and Phocoenidae) are thought to have emerged in the Early Miocene, and they are the most speciose clade of living marine mammals in the world. Previous studies indicated that the distinct innovation of the acoustic (hearing) apparatus would have occurred in the ancestral lineage of the Delphinoidea including their sister group during their initial evolution and diversification. This study aims to understand the relationship among the inner ear labyrinth morphology, hearing and echolocation capabilities and the initial evolution of the Delphinida.

We analyzed six species of kentriodontids—the extinct sister group of the Delphinoidea, and six extinct species of the basal delphinoids (phocoenids and delphinids). We obtained the µCT images and reconstructed 3D models of endocasts of the cochleae in the periotics from each taxon. We performed principal component analysis (PCA) with two different methods. In the first method, we took eight measurements of the cochlea as landmarks, and in the second we took 41 curves from the surface of the cochlea with 371 semi-landmarks.

The result of the first analysis suggested that most kentriodontids were very similar to the modern phocoenids and were overlapped with the extant narrow-band high-frequency (NBHF) species. By contrast, most of the basal phocoenids were not alongside the modern species and had little similarity with NBHF species. On the other hand, the result from the second analysis showed that the kentriodontids and some early delphinoids were separated from most of the modern Odontoceti. These results suggest that the kentriodontids are recognized as NBHF species. Just as same as the modern phocoenids, most kentriodontids were small in body size, they might have had a similar ecological niche to the modern phocoenids. However, their cochlear shape is quite different from the modern species. This could be an indication of parallel and/or convergent evolution in the hearing and echolocation abilities in the Miocene and the present. On the other hand, some basal phocoenids might not have used NBHF echolocation, but their cochlear shapes were remarkably similar to the kentriodontids of the same epoch. It indicates that these early phocoenids are within the moment of the evolution toward the modern species. It also indicates that there might be a shift in niche between the kentriodontids and the later diverging phocoenids in the late Miocene.

**Funding Sources** This study was supported by the Support for Pioneering Research Initiated by the Next Generation (SPRING) and the Japan Society for the Promotion of Science (JSPS).

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Symposium Session: Theropod Flight Origins (Thursday, October 19, 2023, 1:45 PM)

**EVOLUTION OF THE UPSTROKE IN THEROPOD FLIGHT**

Habib, Michael B.

Cardiology, Dinosaur Institute, UCLA, NHMLA, Los Angeles, California, United States

Most work on the origins and early evolution of theropod flight has focused on the evolution and performance of the downstroke phase of the wing cycle. Specializations related to the upstroke have received comparatively less attention. A modeling-based analysis of linkages between upstroke kinematics, sternal morphology, and primary feather morphology finds that tracking upstroke performance specializations across phylogeny yields greater explanatory power than downstroke-specialization models of theropod flight evolution. The keeled sternum, exaggerated feather vane asymmetry, and expanded forelimb skeletal robustness observed in ornithurines (and particularly neornithines) were most likely driven in large part by selection on upstroke performance. Primary feathers only need to have a vane ratio of 3:1 to be aerodynamically asymmetric and achieve "wash-out" twisting during the downstroke when separated. This is found to be sufficient for soaring flight and downstroke wingtip stability. However, the most sophisticated upstrokes among living birds use a rapid and exaggerated passive twisting of the primary feathers, which benefit substantially from larger vane asymmetry ratios. The most robust forelimb skeletons among living birds, defined as size-corrected section modulus, are found among aerial sprinters and aquaflyers – taxa that share expanded supracoracoideus muscles and associated increases in upstroke power capacity. These results stand to fundamentally change how we view the evolution of theropod flight, as upstroke performance is more closely associated with the capacity for short-duration activities (such as vertical launch, pinpoint landings, and tight turns) than with overall aerial range. In this context, the most derived flyers in the Mesozoic may not have been those with the longest flight range. Typically, the modeled ability of fossil to fly long distances has been used as a primary measure of overall flight performance. While this is not in error, additional parameters related to short-range performance should be given greater consideration. Furthermore, there is now robust evidence that powered flight arose multiple times in theropods. I propose that upstroke performance, rather than downstroke performance, best differentiates the aerial abilities of non-avian versus avian theropod flyers.

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Symposium Session: Theropod Flight Origins (Thursday, October 19, 2023, 1:45 PM)

**HETEROCHRONIC CHANGES AS MEANS OF WING EVOLUTION IN PENNARAPTORANS?**

Haidr, Nadia S.[1], Catalano, Santiago[2], Pittman, Michael[1]

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Theropod skull evolution along the lineage leading to birds has been shown to be driven by heterochrony. A series of paedomorphic and peramorphic changes have shaped the theropod skull, giving rise to an avian skull with modules that have separately undergone peramorphism and paedomorphism. Theropod forelimbs evolved significant modifications related to different adaptations, including feeding and aerial behavior. Their forearm evolution has been shown to have an allometric component, with larger animals having shorter forelimbs as well as showing different hand

proportions. A subset of pennaceous feathered pennaraptorans, including birds and select non-avialans, evolved powered flight capabilities using their wings. Wing anatomy and use in juvenile modern birds (e.g. the chukar) has helped to show that 'half a wing' had many more functional and behavioral possibilities in pennaraptorans than previously thought. In this context, dedicated study of ontogenetic trajectories of pennaraptoran wing bones and earlier diverging theropods within a phylogenetic framework has significant potential to shed light on the relationship between forelimb morphological variation, heterochrony and the evolution of flight. New methodologies that infer ancestral landmark-based shape ontogenies and that take into account changes in developmental timing (Phylogenetic Analysis of Shape Ontogenies, PASOS) were compared with other methodologies to test if the wing bones underwent heterochronic changes: if paedomorphic or peramorphic changes occurred, and in which theropod clades. Ontogenetic trajectories obtained by PASOS and complementary methodologies were analyzed and compared. These analyses were based on a landmark configuration that represents the extremes of each of the forearm bones. Using a widely sampled theropod dataset including *Archaeopteryx*, *Anchiornis*, *Jeholornis*, *Sapeornis*, *Confuciusornis*, *Caudipteryx*, and the Scansoriopterygidae, we reveal a series of peramorphic and paedomorphic changes. Results recovered heterochronic evidence for peramorphism in Oviraptorosauria in the lineage leading to *Caudipteryx*, and for paedomorphism in multiple paravian clades seen as a shortening of the offset of their ontogenetic trajectories. This shows that the wing underwent a series of complex heterochronic mechanisms that have involved pera- and paedomorphism as have been observed for the skull.

**Funding Sources** Research Grant Council General Research Fund (17103315, 17120920, 17105221); School of Life Sciences of The Chinese University of Hong Kong (CUHK); Croucher Foundation

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

### ABRASION IS THE PITS: A STUDY OF UNIQUE DAMANGE AT RANCHO LA BREA

Haji-Sheikh, Misty H.[1], Naples, Virginia L.[1], Haji-Sheikh, Michael[2]

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Specimens from Rancho La Brea that may have been in the tar seep for 10,000 years or more have a unique kind of wear. This phenomenon is colloquially termed "pit wear" and results only from circulation within an asphalt seep. This form of wear is distinguishable from other types of surface damage. It primarily consists of defects that resemble smooth-edged gouges and depressions in the compact bone; these depressions often appear different in color from the rest of the bone in the same area. Circulation of the bones through the thick tarry medium where the tar is still active, and the movements of the bones is reminiscent of the way that cooking pasta tumbles constantly in a pot of boiling water, although without heat. Pit wear is a phenomenon that is observed visually. The appearance of external bone surfaces altered by taphonomic events differs, depending on the cause(s). The tools used were measuring tools: a centimeter ruler, a quarter, a dial caliper, a log book, and a Nikon Z6 ii camera with a 24-70/4s lens.

The appearance of fossil specimen surfaces change, depending on the kind of matrix in which they are found (ex. conglomerate, sandstone, siltstone, mudstone, and asphalt). Pit wear can occur on any bone surface and can occur between different species as the animals became trapped at different times and also in the predator/prey cycle. Crania and limb bones are common areas that rub together. Pit wear damage often appears as smooth, dish-shaped gouges with raised ridges and/or depressions in the compact bone (and sometimes deeper). These depressions sometimes differ in color from the rest of the bone in the local area. Gouges may be deep enough to extend through the spongy bone and into the marrow cavity, creating holes. It is possible for these changes to occur to the bone because the specimens are more pliable *in situ* than during the drying, hardening, and shrinking process that occurs after they are removed from the matrix. Plasticity permits bone surfaces to deform into raised ridges without shattering.

When specimens that have been in close proximity to one another are extracted from the asphalt, those that interacted to cause pit wear typically match the shapes of the concavities each caused in the other. Pit wear is a condition that can either hurt or help paleontologists. The identification of distinct pit wear can help avoid misidentification of fossil damage or disease.

Technical Session 11: Archosaurs (Friday, October 20, 2023, 8:00 AM)

**ENIGMATIC ARCHOSAURIAN (DIAPSIDA, ARCHOSAURIA) OSTEODERMS FROM THE UPPER TRIASSIC OF INDIA**

Haldar, Atrayee, Ray, Sanghamitra

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India documents a rich Late Triassic tetrapod fossil record that has been recovered from different Gondwanan horizons, such as the Maleri and Dharmaram formations of the Pranhita-Godavari Basin and the Tiki Formation of the Rewa Basin. The present study focuses on multiple bizarre and enigmatic isolated osteoderms that were recovered from a multitaxic bonebed of the Tiki Formation. These osteoderms may be subdivided into three morphotypes. Morphotype I comprises elliptical, anteroposteriorly elongated osteoderms, the dorsal surface of which is extremely rugose with short ridges and grooves and has a posteriorly recurved horn-like dorsal eminence. The ventral surface is hollow with a deep anteroposteriorly extending groove. Morphotype II includes osteoderms that are subtriangular with a straight medial margin, anteroposteriorly elongated, and possessing a transversely compressed, blunt dorsal keel. The dorsal surface contains short, thick radial ridges and grooves whereas the ventral surface is flat and unornamented. The third morphotype (III) contains a typical compound tripartite osteoderm that is composed of three fused extremely rugose horns, the ventral surface of which contains two fused and narrow grooves.

Taxonomic identification of the Tiki osteoderms is difficult because of their unique morphology, as these do not show similarity with the osteoderms of other Late Triassic armored forms such as the aetosaurs, phytosaurs, rauisuchians and several basal crocodylomorphs. Although spike-like dorsal eminence in the lateral and paramedian osteoderms may be present in a few desmatosuchine aetosaurian taxa, the Tiki osteoderms differ from the former based on its oval to elliptical shape, and absence of an anterior bar and ventral flexion. The osetoderms of other Late Triassic archosaurs are circular to sub-circular or square to rectangular or leaf-shaped, and do not bear the recurved spike-like dorsal eminence that is typical of the Tiki osteoderms. Although there are no records from the Late Triassic, the Tiki osteoderms show similarity with the early-diverging Jurassic thyreophorans based on the long spike-like, recurved dorsal eminence and the tripartite compound morphology. Hence, the current study highlights the presence of a new armored archosaur from India that had osteoderms showing morphological convergence with that of the thyreophoran dinosaurs.

**Funding Sources** Science and Engineering Research Board India (SERB India)

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Education & Outreach Poster Session (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**THE DESIGN AND CONSTRUCTION OF A NEW VIRTUAL OUTREACH STUDIO AT MUSEUM OF THE ROCKIES**

Hall, Ashley E., Hogan, Chelsea, Williams, Scott A., Dobbs, Chris

Montana State University Museum of the Rockies, Bozeman, Montana, United States
At Museum of the Rockies, all Montana school groups are admitted free of charge. However, many schools cannot utilize this benefit due to their distance from the museum. Virtual programming is a powerful tool museums can utilize to reach remote and underserved communities both regionally and globally. Museum of the Rockies has completed a project transforming an outdated media control room into a new virtual outreach space. This new facility, the E.L. Wiegand Digital Learning Studio, produces educational digital learning programs that are broadcast live to classrooms across the world. Over the course of three years, this former media control room was gutted, demolished, rewired, and transformed into a public-facing studio outfitted with new video, recording, and sound equipment. Completed in March of 2023, this state-of-the art studio has allowed MOR educators and scientists to teach dynamic classes on paleontology, paleohistology, archaeology, and geology through Zoom. It is our goal to share our process and procedure in creating this extraordinary programming space with other paleontology museum professionals, as teaching over Zoom is an easy, popular, efficient, and valuable way to extend your museum's footprint through virtual outreach.

**Funding Sources** Funding provided by the E.L. Wiegand Foundation.

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**THE PNEUMATIC SINUSES OF THE TYRANNOSAUROID *BISTAHIEVERSOR SEALEYI***

Hall, Lauren[1], Brusatte, Stephen[2], Williamson, Thomas[3]

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*Bistahieversor sealeyi* was a tyrannosauroid theropod dinosaur from the Late Cretaceous (Campanian), ca. 74 Mya, and was approximately 9 meters in body length. It is known from the Hunter Wash member of the Kirtland Formation in northwestern New Mexico. *Bistahieversor* is phylogenetically positioned as an immediate outgroup to Tyrannosauridae, the clade of derived, large-bodied tyrannosauroids, and therefore a critical species in understanding how tyrannosauroids became apex predators and evolved colossal size.

We used computed tomography (CT) to scan the holotype skull of *Bistahieversor* at Los Alamos National Labs, New Mexico; this scan was used previously to describe the brain, endocranial sinuses, and inner ear. We used this scan to segment the cranial sinuses using the software MIMICS and compared the morphology in *Bistahieversor* to other tyrannosauroids. The segmentation indicates *Bistahieversor* has extensive cranial pneumaticity. Sinuses are present in the lacrimal, jugal, palatine, maxilla, and quadrate. The ectopterygoid was optically, but not x-ray CT, scanned; it is highly likely to be pneumatized due to a large fenestra on the ventral surface. Pneumaticity is not found in the postorbital, squamosal, and quadratojugal.

Pneumatization in the maxilla consists of multiple chambers extending anteriorly from the maxillary fenestra. Pneumatization in the lacrimal arises from the pneumatic fenestra connecting to the antorbital cavity; the sinus is found in the proximal portion of the lacrimal and does not extend into the ventral ramus. Pneumatization in the jugal communicates with the antorbital cavity via the jugal foramen; the sinus is found dorsally and posterior to the foramen. Pneumatization in the palatine connects to the antorbital cavity via a foramen located on the external surface; the sinus occupies most of the palatine. Pneumatization in the quadrate is found above the condyles. The sinus connects to a foramen found posteriorly on the quadrate; a second foramen is present on the flange that creates a second sinus.

The squamosal lacking pneumatization is unusual in comparison to other taxa within Tyrannosauridae; it is not unusual compared to basal members such as *Guanglong* or *Dilong*. Pneumatization of the squamosal is a shared feature among tyrannosaurids. Therefore, a lack of pneumatization corroborates the phylogenetic position of *Bistahieversor* as an outgroup of Tyrannosauridae, indicating a pneumatized squamosal appeared with tyrannosaurids.

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Preparators' Session (Thursday, October 19, 2023, 8:00 AM)

**NEVER GIVE UP, NEVER SURRENDER: PLANNING AND CONSTRUCTING DUST EXTRACTION SYSTEMS IN TWO FOSSIL PREPARATION FACILITIES AT MUSEUM OF THE ROCKIES**

Hall, Lee[1], Williams, Scott A.[2], Meld, Levi[1], Knight, Cassi[1], Scannella, John[1], Metz, Eric T.[1], Lamm, Ellen-Thérèse[1], Dobbs, Chris[3]

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Respirable crystalline silica (RCS) is a common byproduct of fossil preparation. Long term, regular exposure to RCS is the leading global cause of occupational silicosis, an incurable chronic respiratory illness with a high mortality rate. Appropriate mitigation of RCS dust is therefore an immutable requirement for any facility where fossil preparation takes place. Exposure to hazardous levels of RCS (OSHA permissible exposure limit [PEL] = 50 ug/m$^3$) is preventable through use of a dust extraction system outfitted with HEPA filtration. Museum of the Rockies (MOR) recently completed construction and installation of two independent dust collection systems in its main fossil preparation laboratory and its public-facing viewing laboratory. The project was executed in several phases over approximately two years, beginning in the spring of 2021. MOR contracted an independent industrial hygienist to perform baseline (no filtration) air quality testing to verify and quantify that respirable dust and RCS dust were generated by fossil preparation. Resultant data revealed respirable dust levels 800% above OSHA PELs, and RCS levels 250% to 600% above OSHA PELs. Follow up testing in November 2021 and February 2022 was conducted with portable, HEPA filter-equipped dust extractors utilizing the same specimens. Extractors lowered respirable dust levels to less than 2% of OSHA PELs, and RCS levels to less than 25% of OSHA PELs. With this data MOR was able to move ahead with appropriate design parameters for permanent dust collection systems. Specifications included HEPA end filtration, articulated telescopic trunk arms with capture velocities of 500 cubic feet per minute, and sound dampening between machine rooms and lab spaces. Planning passed through several concept phases with system design and material sourcing contracted through an engineering consulting firm. The project went out for bid in the late spring of 2022, and construction began the following October. Several challenges were encountered throughout construction, including lab closure, manufacture lead time, material availability, pandemic-related global supply chain issues, contractor and engineer communication and coordination, and inventory delivery errors. The original completion date of December 2022 was delayed several months with significant completion by April 26, 2023.

**Funding Sources** WEM Foundation

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Technical Session 1: Sauropod & Ornithischian Dinosaurs (Wednesday, October 18, 2023, 8:00 AM)

**BENEATH THE FEET OF GIANTS: A CASE STUDY OF THE POPULATION DYNAMICS OF *ORYCTODROMEUS CUBICULARIS* AND *ORODROMEUS MAKELAI*, TWO POTENTIAL BURROWING DINOSAURS**

Hannebaum, Zakaria[1], Varricchio, David J.[1], Krumenacker, L.J.[2]

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*Orodromeus makelai* is a small-bodied orodromine thescelosaurid dinosaur from the Upper Cretaceous Two Medicine Formation of north central Montana. It’s especially abundant at localities representing attritional settings with bones numbering in the hundreds. This presents an exceedingly rare opportunity to analyze the taphonomy and population dynamics of a small-bodied ornithischian dinosaur, which to our knowledge, has previously only been attempted with the basal ceratopsian *Psittacosaurus lujiatunensis*. *Orodromeus* shares a morphology and taphonomy with the closely related Mid-Cretaceous *Oryctodromeus cubicularis* and thus may share a similar burrowing ecology. Likewise, *Oryctodromeus* provides a modest sample from the Wayn-Vaughn Assemblage for comparison.

Based on hindlimb data alone, the Two Medicine Formation has produced a substantial *Orodromeus* sample (n=133). The size-frequency distribution is bimodal with two peaks corresponding to femora with a length of 11.0 cm and 16.0 cm The larger peak at 11.0 cm consists of juveniles with no more than one LAG. The smaller second peak sits among mature individuals with LAG counts of four to five. This differs from *Oryctodromeus* (n=27), which shows a unimodal distribution skewed to the left. Only three juveniles are represented, with tibiae absent of LAG’s. The size-frequency distribution peaks in subadults with a femora length of 19.0 cm and LAG counts of two to three. Near-adult to adult individuals, emerge with femora 21.0 cm long and LAG counts of four to six. Despite the single peak, two morphotypes emerge among the tibia: a short/robust and a long/gracile morph.

The comparisons of these two assemblages of potential fossorial dinosaurs have not yet yielded any discernable pattern to identify any such behavior based on size-frequency data alone. Bias also plays an important role in the generation of these assemblages. If both species are indeed burrowers, we would expect these assemblages to predominately be a subsurface signal which could differ to the overall survivorship. However, these two dinosaurs provide an important step forward in understanding the taphonomy and population dynamics of small-bodied ornithischians.

**Funding Sources** Undergraduate Scholars Program (Montana State University)

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

relatively high diversity of Simoliophiidae in the Tethys Sea.

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Technical Session 3: Fishes & Amphibians (Wednesday, October 18, 2023, 8:00 AM)

**NEW MATERIAL OF THE EARLY SNAKE *SIMOLIOPHIS* (OPHIDIA, SIMOLIOPHIIDAE) FROM THE UPPER CRETACEOUS BAHARIYA FORMATION OF EGYPT**

Hanning, Lilliana[1], Zak, Catherine[1], McCartney, Jacob[1], Lamanna, Matthew[2], Salem, Belal S.[3], El-Saka, Hossam[4], El-Sayed, Sanaa[5], Sallam, Hesham M.[4]

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Exposures of the Upper Cretaceous (Cenomanian) Bahariya Formation in the Bahariya Oasis of the Western Desert of Egypt preserves a diverse vertebrate fauna, including non-avian dinosaurs, fishes, plesiosaurs, turtles, crocodyliforms, and pterosaurs. Also known from this locality are fossils referred to the early aquatic simoliophiid snake *Simoliophis*. Among simoliophiids, *Simoliophis* is poorly known, with specimens mainly consisting of vertebrae and only sparse cranial elements and ribs. *Simoliophis* has a Tethyan distribution and is known from two species, *S. rochebrunei* of Western Europe and *S. libycus* of North Africa. Specimens of the genus from the Bahariya Formation were originally attributed to *S. rochebrunei*; however, this identification has more recently been questioned. Here we describe new vertebral specimens from the Bahariya Formation and discuss their affinities with the other known species of the genus. The collection includes anterior and posterior trunk vertebrae in various states of preservation. The Egyptian fossils differ from the European and other North African species in several features, including aspects of the neural spines, cotyle-condyle complex, and ventral surface of the centrum, among others. Regional variation in the vertebrae of *Simoliophis* is unusual in comparison with other snakes, but some aspects can be identified in the material, including changes in the morphology of the synapophyses, neural spine, and overall vertebral aspect ratio. The preserved material supports identification of a third species of *Simoliophis* in the Late Cretaceous and expands the

**TOOTH ORIGINS AND THE CONVERGENT EVOLUTION OF SENSORY STRUCTURES**

Haridy, Yara[1], Nanglu, Karma[2], Sharma, Neelima[1], Norris, Sam[1], Ortega-Hernandez, Javier[2], Shubin, Neil[1]

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The evolutionary origin of vertebrae mineralization is complex and under-explored. There is limited information about the origin of the fundamental tissues that make up the vertebrate skeleton. Dentine, enameloid, and acellular bone appear simultaneously in the dermal odontodes of jawless vertebrates in the middle Ordovician. The origin of teeth is widely accepted to stem from dermal odontodes that migrated into the mouth through an evolutionary expansion of tissue competency. Yet little is known about the impetus for the initial evolution of odontodes and what purpose they served in early vertebrates. Historical hypotheses propose several scenarios ranging from defense, to hydrodynamics, to sensation, but clear consensus has yet to emerge. Early vertebrate fossils are scarce and understudied, with fragmentary plates of the putative earliest vertebrates with odontodes such as the Cambrian *Anatolepis* being key. *Anatolepis* reportedly has dentine, a pulp cavity, lamellar basal tissue akin to the acellular bone of heterostracans, and a pore system like that seen in many ostracoderms while completely lacking enamel or enameloid. Histological and SEM images reveal the presence of dentine tubule networks in odontode-like structures. Despite these observations, *Anatolepis* has also been argued to be an arthropod, rendering its significance for early vertebrate evolution controversial. We examined *Anatolepis* and related material from various localities in North America via high-resolution synchrotron, FIB-SEM, and traditional paleohistological methods, then compared them to known vertebrate odontodes and arthropod cuticle structures from both modern and extant taxa. High contrast and high-resolution scan data aligned with early descriptions of *Anatolepis* but also allowed visualization of novel complex structures within the tubercles and pore canal system. At high resolution, the dentine structures which initially seemed obviously vertebrate were revealed to be a part of a complex pore tube system of Cambrian Aglaspid arthropod sensillae. The detailed morphological and histological similarities between odontodes and arthropod cuticle sensillae are remarkable and reveal that odontodes are convergently similar to mechanoreceptors that function to sense pressure exerted on the cuticle. Recent dental studies support a parallel sensory function of dentine and teeth in their ability to act as mechanoreceptors, thereby lending credence to the sensory origins of odontodes.

**Funding Sources** The University of Chicago and the Brinson Foundation

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**NON-UNIFORM DISTRIBUTION OF COCHLEAR FIBERS IN THE CRETACEOUS MERIDIOLESTIDAN *CRONOPIO***

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Here we describe the cochlear endocast of an isolated petrosal attributed to the meridiolestidan mammal *Cronopio* sp. from northern Patagonia. The preserved morphology is remarkable in that it demonstrates a fully coiled cochlear canal (~390°); the presence of the vein of the cochlear aqueduct and primary/secondary lamina, basally; and an apical inflation, possibly for a vestigial lagenar endorgan. Based on current phylogenetic hypotheses the derived (coiled) cochlear morphology seen in *Cronopio* and other meridiolestidans is an example of evolutionary convergence with modern therian mammals (marsupials and placentals).

Another derived feature of this cochlear endocast is the presence of a tractus foraminosus, an ossified trabecular armature which conducts the central processes of cochlear sensory neurons towards the internal auditory meatus. Using µ-CT data from *Cronopio*, we present a geometric analysis quantifying the cross-sectional area, and basal-to-apical position (along the spiral canal), of the entrance foramina into the tractus foraminosus. These measurements show that the cumulative area available for cochlear fibers increases disproportionally at more apical (low frequency) positions. Using subsequent pairwise randomization tests, *Cronopio* is significantly differentiated from the representative therians *Erinaceus* and *Didelphis*; both because of its higher density, and cross-sectional area, of entrance foramina apically.

One interpretation of this result is as a consequence of the requirement to increase fiber diameter and/or depth of myelination of sensory neuron central processes at more apical positions in mammals with “parallel” as opposed to “radial” distributions of the cochlear nerve (i.e. fibers leaving lower-frequency positions travel a longer distance to reach the brainstem). Therefore, the cochlear morphology seen in *Cronopio* may represent an intermediate state in a transition series from a more ancient adaptation for synchronicity (based on increasing fiber conduction velocities) to a more derived one (based on a radial arrangement of equidistant cochlear nerve fibers). Alternative interpretations for this result also include the presence of a low frequency “auditory fovea”, or the distribution of lagenar nerve fibers among the terminal spiral canal foramina

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**ISOTOPIC ANALYSIS AND MOBILITY MAPPING OF COLUMBIAN MAMMOTHS (*MAMMUTHUS COLUMBI*) FROM THE MAMMOTH SITE IN SOUTH DAKOTA**

Harrington, Matthew[1], Widga, Chris[2]

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The Mammoth Site in Hot Springs, South Dakota preserves a unique death assemblage of sub-adult and adult male Columbian mammoths (*Mammuthus columbi*). Extensive work on the site has led to a detailed understanding of the taphonomy of the assemblage; yet the life histories and ecology of these mammoths remain relatively unknown. The use of oxygen, carbon, and strontium isotopes from fossil remains provides excellent insights into both individual and landscape level ecological patterns.

The long growth period of an adult mammoth's molar preserves a multi-year record of the mammoth's life history within the enamel of the tooth. Two molars were systematically micromilled to acquire chronologically ordered samples at 1 mm intervals. For each molar, two micromill samples were taken per interval, allowing a direct comparison of $\delta^{13}C/\delta^{18}O$ values to $^{87}Sr/^{86}Sr$ values. Serially sampled $^{87}Sr/^{86}Sr$ values from this enamel can provide novel insight into the mobility of the individual mammoth over the span of the tooth's growth. In order to accurately predict mobility patterns across a landscape, a high resolution 'isoscape' must be constructed. The viability of an isoscape relies upon both the quantity of measured samples across the study area and the strength of the interpolation models utilized. An $^{87}Sr/^{86}Sr$ isoscape of the central United States, centered around the Black Hills, was generated by a random forest model utilizing 12 covariate explanatory rasters and 193 sample locations. To predict mobility patterns from the isoscape, each micromilled value was buffered to include a half standard deviation above and below the value to account for error and weekly averaging during the enamel's formation. To refine the spatial origin of each sample, regions that were too far removed from the mammoth's viable range, too isolated, or blocked by geographic barriers were filtered out. Results indicate that one of the mammoths remained within the southern and western Black Hills year-round, with no consistent migration patterns. $\delta^{18}O$ seasonality levels vary between the two individuals, suggesting differences in how mammoths utilized the local environment. For the individual with lower seasonality, both in $\delta^{13}C$ and $\delta^{18}O$, it is suggested that the mammoth remained highly local year-round and utilized the presence of hot springs for water and forage. The high level of slopes in the region may explain the restricted mobility and absence of female and juvenile mammoths at the site.

**Funding Sources** Funding: Geological Society of America and the Center of Excellence in Paleontology, East Tennessee State University.

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Technical Session 15: Paleoecology & Paleoclimatology (Friday, October 20, 2023, 1:45 PM)

**COLD CASE #201MA: LATE TRIASSIC TRANSIENT COLD PHASE EXPLAINS TERRESTRIAL TAXONOMIC SELECTIVITY DURING THE END TRIASSIC EXTINCTION**

Hartman, Scott[1], Lovelace, David M.[2], Linzmeier, Benjamin[3]

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It is broadly accepted that the End Triassic Extinction (ETE) was triggered by the onset of volcanism associated with Central Atlantic Magmatic Province emplacement. Prior modeling based on carbon isotope excursions suggest an input of volcanogenic sulfur and 7,500 to 12,500 GT of $CO_2$ resulted in strong, global transient cold phases lasting years to decades, followed by prolonged warming over a period of 1-10 kyr. Terrestrially, this coincides with major faunal and floral upheaval, but the causal relationship between environmental change and selectivity in extinction have not been mechanistically tested. We employed the mechanistic modeling program Niche Mapper on thirteen Late Triassic amniotes to test how changes in thermal conditions before and during the End Triassic Extinction would alter available foraging time, core body temperature, and metabolic costs of thermoregulation. Surprisingly, cold stress appears to be a better predictor of ETE selectivity, with 100% of taxa that suffered extinction showing highly stressed responses to the cold phase while surviving taxa show low or no stress. In contrast, even extreme warming models only predict high stress on 38% of taxa that suffer extinction, while concurrently predicting high levels of heat stress in 60% of taxa that survived the ETE. Although reinforcing selection during subsequent cooling and warming phases likely played an important role in terrestrial ETE ecological upheaval, our results suggest the most extreme global warming models for the event are unlikely, and the sulfur-mediated cold phases may have played a deciding role in survivorship selectivity.

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Technical Session 20: Marine Mammals & Bats (Saturday, October 21, 2023, 1:45 PM)

**A NEARLY COMPLETE SKELETON OF THE STELLER'S SEA COW (*HYDRODAMALIS GIGAS* (ZIMMERMAN, 1780)) FROM THE LOWER PLEISTOCENE OF JAPAN REVEALS SOME ANATOMICAL CHARACTERISTICS**

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The Steller's sea cow, *Hydrodamalis gigas* (Zimmerman, 1780), is a species of herbivorous marine mammal which was distributed in the Bering Sea until 1768. This sea cow is geologically considered an "extant" species since they were still alive at the middle of 18th century. However, the species was driven to extinction by human hunting pressure. Many osteological characters of Stellar's sea cow were described by Steller himself in 1751.

A nearly complete skeleton including skull and mandibular fragments of *Hydrodamalis gigas* from the Lower Pleistocene Iimuro Formation, Komae city, Tokyo, Japan was discovered and excavated in the 2000s and now bears the registration number NMNS PV-21844 at the National Museum of Natural Science, Japan. The skeleton consists of almost all the postcranial bones and parts of skull and mandibles which belonged to a subadult individual. Most of the bones are well preserved and complete and the new discovery reveals that there were 18 pairs of rib bones and the pelvis consisted of two bones. Furthermore, the proximal half of a metacarpal was collected, which is the second reported for this species. There are no reports of distal limb bones of *Hydrodamalis gigas* except for a metacarpal from the specimen Ma-560276 stored at National Museum of Natural History of the Netherlands, and this discovery may add a new clue to reconstruct of their forelimb.

This specimen was excavated from the Lower Pleistocene, about 1.36 - 1.10 Ma, so this is the oldest fossil record of the Steller's sea cow. This discovery will fill the gap of not only the chronological but morphological evolution between *Hydrodamalis gigas* and the late Pliocene - early Pleistocene *H. cuestae*, which is known as an ancestral species to *Hydrodamalis gigas*.

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Technical Session 14: Crocodylomorphs & Turtles (Friday, October 20, 2023, 1:45 PM)

## NEW DWARF SPECIES OF *ALLIGATOR* FROM THE EARLY MIOCENE OF FLORIDA (USA)

Hastings, Alexander K.[1], Schubert, Blaine W.[2]

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The first occurrence of *Alligator* in the fossil record dates back to the Eocene–Oligocene transition, from South Dakota and Nebraska. This species, *A. prenasalis* (adult total length approx. 1.3–1.9 m), is much smaller than the extant species, *A. mississippiensis* (adult total length approx. 3.5–4.5 m). Recently, the oldest occurrence of *Alligator* from Florida was reported, all small individuals from the Late Oligocene (28–26 Ma). We describe here a new species of *Alligator* based on 149 skeletal elements, representing a minimum of six individuals. These fossils were recovered from the Miller fossil site in northern Florida. Based on mammalian biochronology, this site is assigned to the early Hemingfordian (Early Miocene), with an estimated age of ~19 Ma. These fossils are the second oldest known *Alligator* remains in the southeast and the oldest known from relatively complete material.

Remarkably, these fossils indicate an animal of small body size despite relative maturity. Neurocentral suture closure is evident, including in cervical vertebrae. One cervical vertebra has both cervical ribs fully fused onto the centrum. Osteoderms are not only fully developed, but also preserve lateral sutures, and three pairs of osteoderms were found fully fused together. Pitting is deep and pervasive across outer cranial bones and osteoderms, which are most similar to *Alligator* that are well past sexual maturity. Independent of size, this new species can be diagnosed based on a unique combination of 18 morphological characters in the cranium and mandible.

We conducted a phylogenetic analysis including the new taxon with a pre-existing dataset, and also added the recently named *A. hailensis* described from younger deposits in Florida. The dataset includes 115 taxa across 202 characters. Results place this new taxon in a nested grouping of *Alligator* species, between the more basal *A. mcgrewi* of Nebraska and more derived *A. olseni* from Florida. Tracking locations of ancient *Alligator* and body size could indicate that *Alligator* began as a small species in the Great Plains, remained small when they immigrated to the southeastern United States, then got progressively larger in the Neogene. Alternatively, there could be a widespread Paleogene presence of small *Alligator* in the southeast that has not yet been recovered. An improved fossil record for this time and region would help determine which is more likely.

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Education & Outreach Poster Session (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**HAPPY CROCTOBER! DEVELOPING CROCODILE-THEMED 'LEARN FROM HOME' CONTENT AND ADAPTING IT INTO IN-PERSON EDUCATION PROGRAMMING**

Hastings, Alexander K.[1], Groenert, Janet[2], Early, Catherine M.[3], Holm, Jessica[2], Stallnick, Emilie[2]

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The Science Museum of Minnesota (SMM) has long had an active research and outreach program focused on fossil crocodyilforms. In recent years, outreach centered in crocodyliform evolution has a prominent feature in the month of October, taking advantage of the word play and popular hashtag, #Croctober. Starting in 2020, SMM expanded this effort into the virtual domain. A team that combined staff from education and science departments created two lessons that could be easily conducted at home, with common household materials, called 'Learn from Home' activities.

The lesson 'Crocodile Jaw Power' focuses on the jaw mechanics of crocodyliforms, by drawing comparison to a pair of scissors. Participants would note where the greatest force is, and in turn understand better how these predators apply pressure to their prey. This concluded with one of two templates of fun crocodile designs, including one that folds out in a snowflake pattern. The lesson 'Build an Alligator Nest' utilizes piles of laundry to illustrate the insulating methods used by some crocodyliforms to incubate their eggs, including using a thermometer to determine if their clutch would hatch as mostly male or female (illustrating temperature-based sex determination). The full lessons were posted online (hosted on the SMM website) and freely available. In 2022, the team added an additional two lessons. The lesson 'Crocodile Teeth' focuses on the different shapes of crocodyilform teeth and their utility for different types of prey. The lesson 'Crocodile Tail Power' had participants create a model of a crocodile tail out of plastic cups and string, which could even be worn and pulled from side to side to highlight the lateral motion that propels them through the water.

'Crocodile Tail Power' was modified and implemented in a spring summer camp-style program at SMM in 2023. This particular lesson proved a little difficult for campers (aged 9 to 12), due to the fabrication process needing quite a bit of guidance. 'Crocodile Teeth' was more successful, likely due to a simpler step-by-step design and the ability to use modern crocodylian skulls to aid in visualization. The team will continue to implement these 'Learn from Home' lessons in future programming, applying lessons learned from past trials. These will also continue to remain freely available to the public through SMM's website. Informal feedback on these lessons (both at-home & at SMM) was limited but still uniformly positive.

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Technical Session 10: Euarchontoglires & Xenarthra (Friday, October 20, 2023, 8:00 AM)

**NEW RADIOCARBON DATES FOR SHASTA GROUND SLOTH (*NOTHROTHERIOPS SHASTENSIS*) DUNG FROM GYPSUM CAVE, NV, SHOW POTENTIALLY EARLIER INHABITATION AND PROVIDE ADDITIONAL CONTEXT FOR PALEOECOLOGICAL INTERPRETATION**

Haupt, Ryan J.[1], Clementz, Mark T.[2], McDonald, H. Gregory[3]

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Gypsum Cave, near Las Vegas, NV, is a site known for nearly a century for its preservation of soft tissues and trace fossils of Pleistocene taxa such as the Shasta ground sloth, *Nothrotheriops shastensis,* including the preservation of large amounts of dung or coprolites. The large quantities of dung have allowed for various types of analyses including stable isotopes, biomolecular, palynological, and radiocarbon dating. To date, 12 samples from the site have been radiocarbon dated, 11 dung and one bone, producing radiocarbon ages ranging from 11,005±100 to 33,910±3,720. Here we present 12 additional dung radiocarbon dates ranging from 16,675±40 to 32,960±920 (n=11). One sample generated an age of 55,300±3,300, approaching or possibly beyond the measurable limit of $^{14}C$ dating. Four samples produced radiocarbon ages from 16,675±40 to 23,630±80, whereas the remaining seven samples (excluding the potential outlier) range from 30,930±180 to 32,960±920. Unfortunately, these specimens lack stratigraphic context, which somewhat limits our interpretations. However, we do also have stable carbon isotope values from them (ranging from -14.3‰ to -22.6‰) which can provide more context for paleoecological interpretations when integrated with plant remains in the dung. We find that stable carbon isotope values are highly correlated to our radiocarbon data (p=0.0001, $R^2$=0.76), with lower values in older samples suggesting a $C_3$ to CAM/$C_4$ dietary shift in the sloths inhabiting the cave over time, consistent with a cooler and seasonally drier climate as also suggested by the Macrophysical Climate Model. The older of the two age bins, as defined above, has stable carbon isotope values significantly lower than the younger ones ($\mu\pm\sigma$ = -20.08±1.44‰ vs. -15.73±1.34‰, respectively; p=0.001). Caves tend to be thermally buffered against external temperature swings, so it has been suggested that ground sloths used caves as places to stay cool or warm depending on the climate. Ultimately our radiocarbon data suggests periods of consistent inhabitation of places like Gypsum Cave regardless of climatic context but, the presence of two discrete sets of radiometric dates separated by a hiatus suggests there was an interval when sloths did not use the cave. These results continue to help clarify the idea of whether these cave sites were used consistently such as a sheltered place to give birth versus a thermal refugia during unfavorable climatic conditions, or some combination of both.

**Funding Sources** Funding for this project was provided by a Departmental Graduate Research Scholarship from the Department of Geology & Geophysics at the University of Wyoming.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**MORPHOLOGY, MINERALOGY, AND IMPLICATIONS OF VERTEBRATE COPROLITES FROM THE LATE TRIASSIC CHINLE FORMATION OF ARIZONA**

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Coprolites are common in lake-, pond-, and marsh-deposited horizons in the Blue Mesa Member of the Late Triassic Chinle Formation (middle Norian, ~220 Ma). Using a comprehensive methodological approach of gross characterization, scanning electron microscopy, and thin sections, we analyzed the morphology and chemical makeup of a diverse assemblage of coprolites collected from a mixed macro-micro-vertebrate bonebed from the Blue Mesa member (the “coprolite layer,” PFV 396) in Petrified Forest National Park, Arizona. We selected the best-preserved coprolites (n=52) from the collection (n=232) for morphological characterization, from which we identified six morphotypes including: elongate cylindrical (23%), short cylindrical (46%), subrounded (15%), reniform (2%), spiral (8%), and irregular (6%). There were no recognizable bone or scale inclusions, but mineral inclusions, particularly iron oxide minerals, are abundant. Energy-dispersive X-ray spectroscopy of coprolite thin sections suggests the presence of celestine and tabular barite in some specimens, the first time these minerals have been documented in coprolites. These minerals are interpreted as signs of significant seasonality, as the monsoon-dominated climate cycled from the wet season to the dry season. We posit that as lakes and ponds evaporated, the concentration of barium and strontium ions generated during soil formation in the wet season increased. Subsequently, these minerals precipitated in the sulfate-rich fecal material. The lack of boney inclusions in coprolites from the PFV 396 assemblage differs from other coprolite-bearing horizons in the Blue Mesa Member, suggesting significant spatial heterogeneity in depositional environment, predation patterns, or community makeup. The PFV 396 body-fossil assemblage represents a species-rich and tropically complex vertebrate community including terrestrial and aquatic vertebrates. Our results provide a new approach to understanding the ecological interactions, depositional settings, and preservational pathways of continental vertebrate communities and their environments in equatorial Pangaea preceding intervals of climatic change and extinction in the latest Triassic. This work emphasizes the importance of utilizing coprolites to supplement body fossils in fleshing out our understanding of past organisms and their ecological interactions.

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Technical Session 21: Squamates (Saturday, October 21, 2023, 1:45 PM)

**A NEOTROPICAL WET-FOREST SNAKE LINEAGE FROM THE EARLY MIOCENE OF EQUATORIAL AFRICA: BIOGEOGRAPHIC AND PALEOENVIRONMENTAL IMPLICATIONS**

Head, Jason[1], Lawing, Michelle[2], Kyalo Manthi, Fredrick[3], Mutinda, Christina[3], Müller, Johannes[4], Cote, Susanne[5], Peppe, Daniel J.[6], McNulty, Kieran P.[7]

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The highest species richness and ecological diversity of extant snakes are in the tropics, primarily in South Asia and Central and South America. Tropical Africa has relatively lower richness and less diversity, but the evolution of tropical herpetofaunas, and the factors governing diversification through time at continental scales are poorly understood due to an understudied fossil record. The ecologies and geographic distributions of aniliid and uropeltoid snakes are examples. Modern species constitute either a grade or clade of fossorial, primarily wet forest taxa from South America and South Asia. Their distributions have historically been interpreted as Gondwanan vicariance following the isolation of Africa in the Early Cretaceous, but a definitive fossil record for these snakes is depauperate.

Field research in the early Miocene (approx. 19 Mya) Tinderet sequence of western Kenya has produced precloacal vertebrae of an aniliid snake from multiple localities. Specimens possess vertebral apomorphies shared with extant South American *Anilius scytale*, including the morphology of the neural spine and prezygapophyseal angle. Combined with additional fossils from the Eocene of North Africa, the Tinderet records demonstrate an unambiguous past record of an extant neotropical snake lineage in Africa and falsify previous vicariance hypotheses. Recent stable isotopic and palynological studies of Neogene eastern African fossil localities have indicated heterogenous environments, including C4 grasses and wood- to scrubland, associated with vertebrate faunas. Comparing climate parameters of habitats for extant *Anilius* and uropeltoid snakes as ecological analogues to the Tinderet snake with modern ecosystems equivalent to those reconstructed for the eastern African early Miocene demonstrates only limited overlap in precipitation and temperature values. This discord indicates either greater environmental heterogeneity than reconstructed for the early Miocene of eastern Africa, or a greater range of habitat variability in aniliid snakes than observed in extant *Anilius*.

**Funding Sources** JJH was funded by Natural Environment Research Council grant NE/W007576/1. JJH and FKM were funded by a Cambridge Africa ALBORADA grant.

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Colbert Poster Prize Session

**ORIENTATION: A NEW R FUNCTION FOR QUANTIFYING THE DIRECTION AND STRENGTH OF ORIENTATION ON PALEONTOLOGICAL SURFACES AND ITS APPLICATION TO THE EGGS OF OVIRAPTOROSAURIA**

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Researchers have made significant strides in recent years quantitatively analyzing variation in paleobiological surfaces, including the R package ‘molaR’ for measuring dental surfaces. Although this methodology has been successfully co-opted for analyzing the complexity and relief of eggshell surfaces, a metric that captures the orientation of the external ornamentation, a crucial component of eggshell variation in Elongatoolithidae was lacking. Here, we discuss the results of a new R function that expands upon the output of the Orientation Patch Count (OPC) function of molaR, to successfully quantify both the direction and strength of the external eggshell surface ornamentation.

In our analysis of a nest of oviraptorosaurian eggs (NCSM 33576) from the Cedar Mountain Formation of Utah, we were able to see eggshell surface variation between the pairs of eggs on gross inspection but lacked a way of quantifiably assessing this variation in order to statistically test the degree of within-nest variation. We identified three quantifiable elements to external eggshell ornamentation:

complexity, relief, and orientation. For our 3D meshes of the eggs captured with the photogrammetry application Metascan, we captured the complexity and relief with the molaR functions DNE and Slope respectively but were not able to fully quantify observed variation in ornamentation with existing metrics.

Our new function uses the output of the OPC function and analyzes binned faces perpendicular to the direction of ridges and nodes as a proportion of the total surface area. We standardize to a scale from -100 to +100, where -100 is 'perfectly oriented' latitudinally, +100 is 'perfectly' oriented from pole-to-pole, and 0 is no overall orientation direction. When tested on NCSM 33576, we find that the function can distinguish between surfaces that we would identify as 'lineartuberculate' (orientation values>10) and 'dispersituberculate' (orientation values<5) using the current parataxonomic nomenclature. When used in conjunction with these descriptive categories, we now have a much more powerful statistical tool for interpreting variation at multiple hierarchies. This aids with our hypotheses of understanding variation of eggshell ornamentation and its evolutionary drivers, but we would also encourage widespread future application of the process to other paleosurfaces, where orientation of the external morphology could benefit from added quantifying metrics.

**Funding Sources** This material is based upon work supported by the National Science Foundation under Grant No. 1925973

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Symposium Session: Theropod Flight Origins (Thursday, October 19, 2023, 1:45 PM)

## UNSTEADY AERODYNAMIC FEATURES AND WING-WING INTERACTIONS IN MICRORAPTOR FLIGHT

Hefler, Csaba[1], Ying, Wang[2], Grosmougin, Maxime[1], Chotard, Matthieu[1], Pittman, Michael[1]

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*Microraptor* is unlike any contemporary flying animal. It is a small theropod, but with pennaceous feathers on both of its arms and legs as well as on its tail. Naturally this suggests capability for aerial behavior, but it is debated as to how skillful a flyer *Microraptor* was. Several studies evaluated gliding flight scenarios with different wing configurations, although anatomical plausibility of some of the modelled wing arrangements were later questioned. It is shown that *Microraptor* was a capable glider, and later studies have argued that powered flight and ground take-off were possible as well. However, aerodynamic flow features and the role of wing-wing interaction in its flight have not been detailed so far. Considering that this tandem winged flyer operates in the low Reynolds number regime, it is well within the realms of possibility that unsteady wake elements of the forewing could be utilized by the hindwings. In other configurations the wings may simply operate as one lift generating unit with morphological adjustments of the effective chordwise camber. Given the possibility of *Microraptor* to adapt its wing setup to its flight mission, it remains a question why this tandem winged evolutionary flight experiment did not pass onto modern bird relatives. To answer this question, we numerically investigate the aerodynamic features present in *Microraptor* flight. We present results on unsteady aerodynamics involving the first known detection of vortex shedding in a fossil paravian species as well as the aerodynamic consequences of wing-wing interaction in *Microraptor* gliding with an outlook into powered flight.

**Funding Sources** Research Grant Council General Research Fund (17103315, 17120920, 17105221); School of Life Sciences of The Chinese University of Hong Kong (CUHK); Croucher Foundation

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

## THE MORPHOLOGY OF TANYSTROPHEIDS (REPTILIA ARCHOSAUROMORPHA) OF THE UPPER TRIASSIC (REVUELTIAN EARLY-MID NORIAN) HOMESTEAD SITE IN EAST CENTRAL NEW MEXICO

Heidenfelder, Jeremy C.[1], Heckert, Andrew B.[1], Pugh, Isaac[2], Nesbitt, Sterling J.[2], Lauer, Rene[3], Lauer, Bruce[3]

[1]Geological & Environmental Sciences, Appalachian State University, Boone, North Carolina, United States, [2]Department of Geosciences, Virginia Tech, Blacksburg, Virginia, United States, [3]The Lauer

Foundation for Paleontology, Science and Education, Wheaton, Illinois, United States

The Triassic is a period of significant diversification among archosauromorphs, with many taxa developing unique *bauplans*. Among these new body plans are elongated necks. There are various mechanisms of neck elongation; some taxa add cervical vertebrae and/or co-opt dorsal vertebrae, while others lengthen individual cervical vertebrae to acquire long necks. Tanystropheids are an extinct clade of Triassic archosauromorph reptiles characterized by hyperelongate cervical vertebrae in derived members. Tanystropheids had a broad, principally Laurasian geographic range, but are rare and only known from microvertebrate fossils in the western United States. We examined specimens from the nonmarine Upper Triassic Homestead locality (Revueltian, early-mid Norian) in east-central New Mexico in the Garita Creek Formation. These are among the youngest known tanystropheids from North America, if not globally. We have identified two femora and 16 vertebrae (eight cervicals, six caudals, and two dorsals) from the thousands of Homestead fossils as tanystropheid. One complete cervical vertebra is amphicoelous, with a ratio of centrum length vs. height at the anterior margin of 6.4, a synapomorphy of the tanystropheids *Tanystropheus* and *Amotasaurus*. This cervical also lacks a ventromedial keel, a character state of *Tanystropheus* and *Tanytrachelos*. Two broken cervicals are hollow in cross-section, a character state seen in *Tanystropheus*. The caudal and dorsal vertebrae are identified as tanystropheid because they are procoelous, a synapomorphy of the tanystropheids *Langobardisaurus* and *Tanytrachelos*. Additionally, two caudal vertebrae have an anterior paramedian ridge similar in morphology to *Langobardisaurus* and *Tanystropheus*. The two dorsals have a centrum length-to-height ratio of 1.83 and 1.77, respectively, falling within the published range of 1.48-2.04 identified as a synapomorphy of Tanystropheidae. Both femora lack a proximodorsal incline in the proximal head of the femur, a character state also shared by *Langobardisaurus* and *Tanytrachelos*. Hyperelongate tanystropheids are typically associated with marine or near-marine coastal environments, but the elongated cervicals in this assemblage indicate that some hyperelongate tanystropheids lived in freshwater environments, possibly alongside other procoelous tanystropheids. Homestead tanystropheids are rare but may represent two species, highlighting the importance of extensive microvertebrate collections.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**A NEW ANGUIMORPH FROM THE HELL CREEK FORMATION WITH POTENTIAL AFFINITIES TO THE SHINISAURIA**

Heise, Patrick I.

Earth Sciences, Montana State University, Bozeman, Montana, United States

During the Maastrichtian, North America saw a high diversity of squamates, including multiple taxa reported from the Hell Creek Formation. Squamate material continues to be collected from Hell Creek Formation localities, though some of this material remains undescribed. In 2000, *Tyrannosaurus rex* specimen MOR 1125 “B-rex” was discovered in the lower Hell Creek Formation in Garfield County, Montana. Among the material recovered from this locality is an undescribed lizard parietal.

A preliminary phylogenetic analysis, coupled with anatomical comparisons to other squamates, indicates anguimorph affinities for the MOR 1125 lizard parietal. Anguimorphs reported from the Hell Creek and other Maastrichtian age formations of North America include anguids, xenosaurids, and varanoids. However, the specimen’s combination of features does not closely align with the morphology of any reported anguimorph taxa from the Maastrichtian of North America. Instead, these features more closely align to morphologies seen in the Shinisauria and *Carusia*.

Shared features between the MOR 1125 lizard parietal, the Shinisauria, and *Carusia* include a transverse anterior margin; the absence of shields and an unambiguous interparietal sulcus; an anteriorly shifted parietal foramen; an overall hourglass shape with concave lateral margins; long supratemporal processes that project posterolaterally; and a continuous, strongly concave posterior margin absent of medial extensions. The specimen shares additional features with *Carusia* that include a ventral lateral margin that is not visible in dorsal view and supratemporal processes that curve slightly medially at their posterior end. However, the specimen lacks prominent osteodermal incrustations—a character that seems to be ubiquitous in *Carusia* and its relatives. Instead, its surface textures resemble the subtler rugosities seen in most members of the Shinisauria.

I suggest that the MOR 1125 lizard parietal likely represents a new taxon of anguimorph lizard from the Hell Creek Formation with potential affinities to the Shinisauria. A description of this specimen would not only add to our understanding of squamate biodiversity from the Hell Creek Formation but could also potentially expand our knowledge of the poorly known geographic distribution of the Shinisauria through time.

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Preparators' Poster Session (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**AN IMPROVED SYSTEM FOR STORAGE OF MICROFOSSILS AT CARNEGIE MUSEUM OF NATURAL HISTORY**

Henrici, Amy C.

Vertebrate Paleontology, Carnegie Museum of Natural History, Pittsburgh, Pennsylvania, United States

The vertebrate fossil collection at Carnegie Museum of Natural History (CM) contains numerous microfossils, which can be challenging to store. A variety of storage methods have been used in the past, but most have proved inadequate. The most commonly used method, which has evolved over time, is to place vials housing microfossils into wooden vial holders. Individual fossils are typically housed in gel caps placed into 2-dram glass vials, which have a thin piece of ethafoam padding on the bottom. The museum acronym and catalog number are written on the gel cap. A specimen label is wrapped around the inside of the vial. Corks bearing the museum acronym and catalog number are used to close the vials. This provides a relatively light-free environment, which helps to prevent breakdown of the gel caps. The vials are placed in wooden vial holders designed to fit into the specimen drawers. These holders can accommodate several vial sizes, as long as they do not exceed the height of the drawer. Taxon labels are placed in the vial holders. In the past, archival materials and pens were not used, which led to fading of labels. Presently, specimen labels are printed on acid-free paper and taxon labels are made from acid-free file folders. All hand labeling is done with pigma ink pens.

The wooden vial holders are the most significant problem with this system. They were originally made by drilling a grid of holes in a "two-by-four" piece of wood. Later they were custom built by museum carpenters who put a grid made of particle board into a rectangular, plywood box. The result is a heavy vial holder with openings that do not securely hold the vials, use space efficiently, and are expensive. A solution was to modify a technique used by the University of California Museum of Paleontology, Berkeley, that uses light fixture grids to hold vials. At CM we had the museum carpenters cut the light fixture grids to fit into specimen trays. The result is a light-weight, space efficient, and inexpensive vial holder. Half-dram sized vials fit snugly into the grid, and this vial size is large enough to hold the specimen label, foam padding on the vial bottom, and a specimen in a gel cap. The standard-sized taxon tags used in the wooden vial holders had to be reduced in size to better fit the new system. Now 1200 vials fit into one drawer, as compared to 378 that fit when using the old system, and the weight of a drawer with empty vial holders is now 10 pounds compared to 15 pounds.

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Technical Session 10: Euarchontoglires & Xenarthra (Friday, October 20, 2023, 8:00 AM)

**PUTTING THE "WHO" IN HUTIA: A COMPREHENSIVE ISOTOPIC EVALUATION OF HISPANIOLA'S RECENTLY EXTINCT RODENTS**

Hensley, Andrew K.[1], Crowley, Brooke E.[2], Viñola-López, Lazaro W.[3], Cooke, Siobhan B.[4]

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Until recently, Hispaniola boasted at least ten endemic caviomorph rodent species. Today, just one remains (*Plagiodontia aedium*), and non-endemic murid rats and mice are prevalent. We know surprisingly little about *P. aedium* and even less about the extinct species. Understanding how these rodents coexisted and characterizing their environments provides crucial context for reconstructing the ecological niches they filled and the causes of their extinction. Recent investigations into the morphology and phylogeny of Hispaniola's rodents, and preliminary isotopic data from bone collagen and tooth enamel, indicate likely niche partitioning and potential competition with murid rats. Here, we present the first large-scale isotopic investigation of rodents from the Tiburon Peninsula in southwestern Hispaniola. We measured collagen $\delta^{13}C$ and $\delta^{15}N$ values for over 200 specimens from seven endemic species (*Plagiodontia aedium*, *P. ipnaeum*, *Rhizoplagiodontia lemkei*, *Isolonodon portoricensis*, *I. montanus*, *Hexolobodon phenax*, *Brotomys* sp.) and invasive *Rattus*. Specimens came from three sites: Trouing Jérémie 5 (TJ5) and Trouing Marassa (TM), which are both deep sinkholes, and Trou John Paul (TJP), which is a chambered cave system. Radiocarbon dates suggest specimens have been accumulating at both TJ5 and TM since the terminal Pleistocene but are limited to the past 2000 years at TJP. There also appear to be temporal differences among rodent taxa at TJ5 and TM (with *H. phenax*, *P. ipnaeum*, and *I. montanus* dating to the early to mid-Holocene and *Brotomys* sp., *R. lemkei*, and *I. portoricensis*, dating to the late Holocene). Isotopic differences among taxa within sites indicate niche partitioning. Isotopic overlap between *Rattus*, *Brotomys* sp., and *I. portoricensis* at all sites, as well as *H. phenax* at TM, suggests *Rattus* either competed with these extinct taxa or filled their vacated niches. Isotopic differences among sites for some taxa (*H. phenax*, *I. portoricensis*) may indicate regional differences in vegetation or variable foraging ecology. Temporal isotopic trends may also exist for *P. ipnaeum* and *R. lemkei* at TM and TJ5 respectively, which may reflect changing local conditions. Intriguingly, some taxa (*Brotomys* sp. at TJ5 and *I. portoricensis* at TJP) have highly variable $\delta^{15}N$ values (ca. 5‰) that are not temporal artifacts. It is possible that these are remains of juveniles or individuals that lived elsewhere on the Tiburon and were deposited at these sites by birds of prey.

**Funding Sources** Funding provided by NSF EAR-2047817 (to SBC) and EAR-2047818 (to BEC).

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

## PALEOENVIRONMENTAL RECONSTRUCTION OF A MIDDLE MIOCENE HOMINOID FOSSIL SITE IN WEST TURKANA, KENYA

Herold, Joslyn I.[1], Lukens, William[1], Rossie, James B.[2], Cote, Susanne M.[3], Peppe, Daniel J.[4], Deino, Alan L.[5]

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The Turkana Basin of northern Kenya, eastern Africa, is a globally significant location for researching human and ape evolution. Geologic research at fossil sites in this region provides critical paleoenvironmental context for fossil assemblages. In this study, we analyzed paleosols (fossil soils) to reconstruct the paleoenvironment associated with the Esha fossil locality (ca. 12 - 13.8 Ma) in West Turkana, Kenya. Three paleosols were systematically described in the field within a stratigraphic interval that includes newly discovered hominoid fossils. Field observations of the paleosols included documentation of paleosol horizon types, pedogenic structure, Munsell color, root traces, grain size, and mineralogy as baseline environmental indicators. A total of 14 samples were recovered for elemental and isotopic analysis. Bulk samples were prepared for elemental analysis using X-ray fluorescence (XRF) to assess elemental weathering in each paleosol profile. Paleoprecipitation estimates using the random forest proxy for mean annual precipitation (RF-MAP) are subhumid (500-1000 mm), consistent with modern woodland and savanna biomes. Some samples show elevated calcium and sodium oxide concentrations, which we attribute to diagenetic alteration via zeolite and carbonate cementation. Our ongoing work will include organic carbon stable isotope analysis for paleovegetation reconstruction, as well as mineralogical and petrographic analyses to better characterize ancient soil processes and to identify horizons that are diagenetically compromised.

**Funding Sources** Funding was provided by the Leakey Foundation (WEL).

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Preparators' Session (Thursday, October 19, 2023, 8:00 AM)

## NO TOUCH TRANSFER OF SKIN IMPRESSION TO RESIN PRINT: APPLICATION OF THE LINDOE TECHNIQUE

Herzog, Lisa, Anné, Jennifer, Lund, Eric K., Knowles, Aubrey, Avrahami, Haviv M., Zanno, Lindsay E.

NC Museum of Natural Sciences, Raleigh, North Carolina, United States

Replicating fossils for research, exhibit, or educational purposes is a common endeavor in paleontology. Recent advances in surface scanning and 3D resin printing have made the process more accessible for specimens that cannot be handled or chemically altered by the application of molding materials. The end product is a highly accurate replica of the original specimen in a solid color. In some cases, reproduction of the original coloration is desirable to indicate soft tissue preservation that has no physical structure. The Lindoe Technique was developed in the 1970s to create realistic replicas of low-relief fossils such as leaves and insects. The replica is achieved by adhering paper-printed fossil images that have been transferred to a flexible layer of cured matte medium onto blank matrix slabs. Here we report on employing this method to produce a touchable, highly accurate reproduction of a well-preserved tyrannosaur skin impression that can be used for education and exhibition. The specimen was surface scanned in high resolution using the Object Capture API photogrammetry based Metascan Application and photographed in high resolution to produce a color print on standard copy paper. The surface scan was edited in Blender 3.4.1 for 3D printing and a photopolymer resin print was produced. The Lindoe Technique has traditionally been performed on porous stone/matrix blanks. Concern about matte medium’s bonding ability to a non-porous resin was ameliorated after we successfully tested the method with a smaller fossil leaf specimen. Producing an image that, after transfer, reflected an accurate coloration and contrast to the original proved to be a challenge. We recommend enhancing the image in photo-editing software in preparation for the technique because some image contrast is lost through the transfer to matte medium. To compensate, the saturation, contrast, and brightness should be modified beyond what would appear to be acceptable digitally. The Lindoe method worked well applied to photopolymer resin and proved to be a useful tool to replicate the very delicate impression of skin we wish to make more accessible for museum visitors.

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**AVIFAUNA FROM THE NSUNGWE FORMATION (LATE OLIGOCENE) OF THE RUKWA RIFT BASIN, EASTERN AFRICA**

Hieronymus, Tobin[1], O'Connor, Patrick M.[2], Mtelela, Cassy[3], Roberts, Eric M.[4], Stevens, Nancy J.[2]

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The late Eocene to Miocene avifaunas of continental Africa and western Asia provide a window into the stepwise assembly of Recent avian communities in these regions. Here we provide a systematic description of an avifauna from the Nsungwe 2 locality in the Songwe Member of the Nsungwe Formation, late Oligocene of Tanzania (24.95 Ma). The recovered fossils consist of an array of mostly isolated postcrania (e.g., humeri, tarsometatarsi) and select craniomandibular elements (e.g., quadrate, posterior mandible). Preliminary identification allows the assignment of certain isolated bones to Anhingidae, Gruidae, and Pelecanidae, all groups that are generally consistent with the fluvial setting interpreted for this locality based on sedimentology. The presence of anhingid material in the Nsungwe Formation is contemporaneous with the oldest record for the family in Australia, suggesting a widespread geographic distribution at the time. Material referred to Pelecanidae represents the earliest preservation of this taxon at an inland, terrestrial fluvial setting. Though this locality is closer in age to early Oligocene localities (e.g., like the Fayum Depression in northern Africa), the presence of both anhingids and pelecanids renders the Nsungwe 2 avifauna as more similar to much later Miocene avifaunas, such as those found at Ruwais, Lothagam, Toros Menalla, and Adu Asa.

**Funding Sources** NSF EAR 0617561, BCS 1127164, EAR 1349825, BCS 1638796

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Virtual Posters

**AN ASSEMBLAGE OF VERTEBRATE MACROFOSSILS AND MICROFOSSILS FROM THE LATE CRETACEOUS OF SENEGAL**

Hill, Robert V.[1], Sarr, Raphaël[2], Jenkins, Xavier A.[3], Tapanila, Leif[3], O'Leary, Maureen A.[4]

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In western Senegal, fossiliferous strata that span the Cretaceous-Paleogene boundary have been recognized for nearly a century. More recently, an integrated picture of the interrelationships of these deposits has begun to emerge. We describe newly discovered vertebrate fossils from the North Quarry of Popenguine. At this locality, the Maastrichtian Cap de Naze Formation transitions, albeit unconformably, to the Danian Ndayane Formation. The Thanetian Popenguine Formation, in turn, lies unconformably on either the Ndayane Formation or on the Cap de Naze Formation.

Vertebrate fossils from the Maastrichtian Cap de Naze Formation at the North Quarry include isolated teeth and jaw elements of pycnodont fishes, caudal vertebrae, metapodials, and teeth of dyrosaurid crocodyliforms, and elements of the carapace and plastron of a pleurodiran turtle. The turtle and dyrosaurid remains represent the oldest and first known Cretaceous representatives of these clades from Senegal. In addition to vertebrate remains, we discovered coprolites and the internal molds of turritellid and naticid mollusks.

Screenwashing from this deposit revealed that the sediment itself also consists of abundant microscopic fossils, constituting a bioclastic matrix. The majority of these bioclasts are ovoid coprolites. Additional sub-macroscopic fossils include osteichthyan vertebrae and cranial fragments. Siluriform dorsal and pectoral spines are also present, along with shark dermal denticles, invertebrates such as corals, and possible otoliths. These microfossils document a far less conspicuous portion of the paleobiodiversity.

We describe the stratigraphy of this locality and incorporate it into a new correlated section that ties together three other Late Cretaceous-Early Paleogene fossiliferous localities of the Senegalese-Mauritanian Basin. Particularly noteworthy is the presence at the North Quarry of fossiliferous Danian rocks, which remain rare elsewhere in West Africa.

**Funding Sources** We gratefully acknowledge funding from the National Science Foundation and National Geographic Society.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

## TELEOSTEAN FISHES FROM THE MIDDLE EOCENE HABIB RAHI AND DOMANDA FORMATIONS OF PAKISTAN

Hilton, Eric J.[1], DeHaan, Lindsey[2], El-Sayed, Sanaa[3], Montalvo, Miguel[1], Saad, Hadeel[2], Friedman, Matt[2]

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The middle Eocene (Lutetian) Habib Rahi and Domanda formations of Pakistan yield three distinct fish faunas from different marine depositional settings. Here we establish the composition of these fish assemblages, providing a major skeleton-based picture of ichthyofaunal composition in the Indo-West Pacific (IWP) during a critical interval in the evolution of its modern marine fish fauna. Fishes from the Habib Rahi Formation are preserved in slabs of pale, platy limestone. These specimens are fully articulated, but the current, unprepared state of the specimens restricts anatomical information to only the coarsest features (e.g., body shape) that are of limited systematic utility and do not permit identification, in most cases, beyond the family level. Nevertheless, this formation has produced putative members of Osteolgossidae, Clupeomorpha, Ephippidae, Carangidae, Scombridae, and Palaeorhynchidae. The fish fauna of the Domanda Formation is preserved in at least three distinct lithologies. The first of these, the so-called ‘paper shales’, yield fossils that are heavily compressed and often covered by thin laminae of sediment to the degree that the enclosed fossil is only hinted at externally. These slabs are highly fissile and cannot be easily prepared mechanically, and their plate-like geometry makes them unsuitable for mCT scanning. However, digital radiography provides high-resolution images of skeletal anatomy in fossils that are, in many cases, comparable in quality to images taken from modern specimens. Taxa from this unit include members of Clupeomorpha, Menidae, and Carangidae. The second comprises variegated, laminated mudstones yielding small specimens belonging to Osteoglossidae, Clupeomorpha, Menidae, Carangidae and undetermined Percomorpha. The third and final fish-bearing component of the Domanda Formation consists of unlaminated mudstones that vary in color from green to brown. Fossils from these layers can be preserved uncrushed and in three dimensions, and include a large number of skulls, presumably because such remains are more easily recognized in the field. Taxa from this unit include members of Engrauloidea, Siluriformes, Centropomidae, Carangidae, Menidae, and Sphyraenidae. This taxonomic survey triples the number skeleton-based taxa from the Paleogene of the IWP and will serve as the basis for future comparisons of the Eocene fish faunas of the Indian Ocean to other Cenozoic marine faunas and the modern fauna of the IWP.

**Funding Sources** National Science Foundation DEB- 2017822 and DEB-2016120

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**A NEW JANASSID PETALODONT (CHONDRICHTHYES, PETALODONTIFORMES, JANASSIDAE) FROM THE MIDDLE MISSISSIPPIAN (VISÈAN) STE. GENVIEVE FORMATION FROM MAMMOTH CAVE NATIONAL PARK, KENTUCKY, USA**

Hodnet, John-Paul M.[1], Toomey, Rickard[2], Olson, Rickard[2], Tweet, Justin[3], Santucci, Vincent[3]

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Members of the petalodont family Janassidae are unique chondrichthyans that evolved monocuspid sigmoidal teeth with lingual longitudinal ridges (cristae), dorsoventrally compressed skate-like bodies, and broad pectoral fins as seen in the type species for the family, *Janassa bituminosa* from the Middle Permian. *Janassa* is known from several species, most based on isolated teeth, spanning from the Middle Mississippian to the Middle Permian. All *Janassa* species have teeth with a single wide spatulate-shaped crown and transverse cristae that are relatively completely horizontal across the lingual surface of the tooth. However, the number and general morphology of lingual cristae in *Janassa* is variable. Included also in the Janassidae is the Middle Mississippian *Cypripediodens cristatus*, which has a narrow-pointed chisel-like cusp and a distinct lingual cusp formed from the U-shaped lingual cristae; the Middle to Late Mississippian *Cavusodus whitei*, which has a narrow-pointed though robust chisel-like cusp and enlarged U-shaped lingual cristae; and the Late Pennsylvanian *Cholodus inaequalis* which has a narrow chisel-like cusp and robust V-shaped lingual cristae. Here we present a new janassid petalodont from the Middle Mississippian (Viséan) Ste. Genevieve Formation from Mammoth Cave National Park (MACA), Kentucky. The new janassid taxon from MACA is represented by more than 20 isolated teeth from all the major tooth family positions and includes juvenile to adult specimens. These teeth were collected from the Joppa Member of the Ste. Genevieve Formation, which represents a biostrom deposit rich with horn corals, bryozoans, brachiopods, and echinoderms. The new janassid taxon differs from *Janassa*, *Cypripediodens*, *Cavusodus*, and *Cholodus* in having narrow and rounded spoon-like like cusps and multiple fine V to U-shaped lingual cristae. *Cholodus* and *Cavusodus* have a few and relatively robust U to V-shaped lingual cristae. Tentative reconstruction of the new taxon's dentition proposes that the diamond-shaped symphysial teeth are flanked by three lateral teeth that progressively reduced in longitudinal length and widen mesiodistally anteroposteriorly; forming a fan-like arrangement. The upper dentition is also notably longer than the lower dentition. Longitudinal wear of the lingual cristae on some of the teeth of this new taxon support previous suggestions that the lingual surfaces of janassid teeth were used for crushing or at least gripping durable food items.

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Technical Session 2: Early Mammals & Carnivora (Wednesday, October 18, 2023, 8:00 AM)

**ESTIMATING HEARING CAPABILITY OF CARNIVORANS USING DYNAMIC FINITE ELEMENT METHODS**

Hoeflich, Jennifer, Liu, Juan

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Considerable work has been done examining the morphology of middle ear ossicles of extant and extinct mammals, however, the methodology on estimation of hearing capability of extinct mammals is not yet available. In this study, we aim to construct a generalized protocol for modeling the middle ear of carnivorans that can be used to assess sound conduction performance at various frequencies and in different species. To do this, we created a dynamic finite element (dFE) model for the middle ear of the red fox (*Vulpes vulpes*). We scanned the skull of a red fox using X-ray Computer Tomography (CT) at the FAVE Lab (GE Phoenix Nanotom M). The middle ear ossicles of the red fox were segmented out from the CT images (voxel size 25.0 µm) using Avizo, then converted to CAD mesh in GeomagicWrap. We then constructed dFE models using the mesh with known anatomical boundary conditions and articulations in ANSYS Workbench. Our mammalian middle ear modeling protocol was modified from dynamic finite element analysis (dFEA) protocol on hearing study of otophysan fish. The material properties and ossicle dynamics were adopted from dFEA analysis of human hearing ossicles from the literature. The joint between the malleus and incus in carnivorans is immobile, as such we modeled them as two separate but bonded entities. While modeling the fluid dynamics of the cochlea was beyond the scope of the model, we were able to model the impedance of the fluid with a spring. The model, using the ossicle meshes extracted from the fox CT images and generalized carnivoran middle ear parameters including commonly ossified ligaments, was successfully able to simulate the auditory responses of the ossicles using harmonic analysis. The analysis subsequently estimated a resonant (most sensitive) frequency of ~4 KHz and a region of maximum peripheral sensitivity (frequencies audible within 20 dB of the most sensitive) of 0.17 - 9.5 KHz. These results were validated by experimental audiograms of red fox from the literature. However, the result of our model suggested a broader range of the maximum peripheral frequencies (0.11 - 6 KHz as published experimental data). This discrepancy in the maximum peripheral frequencies might be attributed to limitations of experimental method or suggest that further fine-tuning of the model is necessary. Our next step is to test this model with other extant carnivorans before applying it to extinct carnivorans.

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Technical Session 2: Early Mammals & Carnivora (Wednesday, October 18, 2023, 8:00 AM)

**THE STAPES OF THE BASAL MAMMALIAFORM *MORGANUCODON***

Hoffmann, Simone[1], Shahid, Ramza[1], Gill, Pamela[2]

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For the past 40 years stapedial morphology has been assumed to be known for *Morganucodon* based on the description by Kenneth Kermack and colleagues in 1981. Twelve isolated stapes were assigned to *Morganucodon watsoni*, all from the Early Jurassic St Brides fissure fillings. The stapes were recovered through screen washing of the depauperate Pant 2 fissure, collected in 1955, and, along with other mammaliaform cranial material, referred to the predominant mammaliaform, *Morganucodon*. Here we describe two stapes from the St. Brides fissures suite Pant 2 and Pontalun 3 that are preserved in association with the petrosal. The stapes were displaced into the cochlear cavity and with near certainty belonged to the same individuals as the petrosals, which are indistinguishable from those of *Morganucodon*. Both stapes are fragmentary and only preserve the stapedial footplate and partial crura. Despite the partial preservation, the morphology is near identical and differs in crucial ways from the previously published stapes: (1) the stapedial footplate is oval rather than near circular; (2) the anterior margin of the stapedial footplate is bend upward rather than straight; (3) the internal aspect of the footplate lacks a central depression; (4) the anterior crus is in a more marginal position and not central; (5) the anterior and posterior crus are widely separated and near parallel, rather than diverge from the center of the footplate. Interestingly, the stapes presented here also differ from those of other basal mammaliaforms such as docodontans and are in various features more similar to those of early mammals including multituberculates, eutriconodontan and spalacotheroids. Reconciling the appearance of two mammaliaform stapedial morphotypes in the St. Brides fissures presents challenges. It might be tempting to assign either the 12 isolated stapes or the two petrosals with enclosed stapes to the associated mammaliaform *Kuehneotherium*, except that the latter is extremely rare in the Pant 2 fissure material collected in 1955, and in the Pontalun 3 fissure. In addition, assigning the stapes and associated petrosals to *Kuehneotherium* would also imply that *Kuehneotherium* and *Morganucodon* have near

identical petrosals, but significantly different stapes. Although we cannot currently solve this conundrum, we need to place the morphology on record.

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Romer Prize Session (Thursday, October 19, 2023, 8:00 AM)

**EXPERIMENTAL EXAMINATION OF PENNARAPTORAN NESTING HABITS AND THE TRANSITION FROM CROCODILIAN-LIKE NEST GUARDING TO AVIAN CONTACT INCUBATION**

Hogan, Jason D.

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The derived avian habit of contact incubating fully exposed eggs likely evolved from basal crocodilian-like guarding of buried eggs, but today's stark dichotomy offers few clues on how this transition took place. Most non-avian dinosaurs fully buried their eggs, but pennaraptoran theropods, the group that eventually gave rise to birds, only partially buried their clutches—a conspicuous intermediate between modern practices. Oviraptorosaurs, the dinosaurs that yield the bulk of the pennaraptoran reproductive fossil record, used highly unusual nest structures consisting of three-dimensionally distributed rings of egg pairs within the walls of a volcano shaped sediment mound. This odd construction is unseen amongst modern vertebrates, and even partial egg burial itself is extremely rare. Some researchers suggest that nest-attending pennaraptorans were guarding their clutches, like modern crocodilians, while other researchers argue that these adults may have contact incubated instead. Because these nests lack decent modern analogues, a series of actualistic experiments was undertaken to better understand pennaraptorans' capacity for contact incubation. A surrogate dinosaur was built to approximate the body mass and temperature of a mid-sized pennaraptoran, then placed atop an oviraptorosaur-style nest containing 36 infertile emu eggs. Thermometers tracked energy flow throughout the system. In each experiment, egg temperatures rose significantly beyond ambient. Additionally, the surrogate's daily energy usage was comparable to that of incubating emus, indicating that the nest system did not require excessive energy input to warm the eggs. Final egg temperatures were above crocodilian values and below avian. However, the results may be conservative due to experimental parameters. These results support the possibility that some pennaraptorans may have used adult-generated energy to warm their eggs. Results also indicate that it may be possible for an endotherm to warm a fully buried clutch via metabolic energy. Perhaps nest guarding, enacted by endothermic archosaurs, led to an indirect form of contact incubation whereby metabolic energy warmed a buried clutch. Through time, selection could have pushed for shallower clutches to increasingly benefit from adult energy—eventually leading to egg exposure. This hypothesis provides an explanation for how avian-style contact incubation of exposed eggs could have evolved from crocodilian-like guarding of buried eggs.

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Technical Session 16: Theropods - I (Saturday, October 21, 2023, 8:00 AM)

**A REVISION OF THE DROMAEOSAURIDS OF THE CRETACEOUS (CAMPANIAN) TWO MEDICINE FORMATION OF MONTANA, U.S.A.**

Hohman, Charlotte J.[1], Varricchio, David J.[1], Napoli, James G.[2], McDonald, Andrew T.[3]

[1]Department of Earth Sciences, Montana State University, Bozeman, California, United States, [2]North Carolina State University, Raleigh, North Carolina, United States, [3]Western Science Center, Hemet, California, United States

Dromaeosaurid specimens have been collected from the Campanian Two Medicine Formation (TMF) over the last few decades, including the holotype of *Bambiraptor* and associated larger bones, and multiple specimens that have not received a proper description, including two maxillae (MOR 553S-7.30.91.274, MOR 9753) and two postcranial skeletons (MOR 660, MOR 721). All specimens have been referred to *Saurornitholestes* except MOR 553S-7.30.91.274, which has been referred to cf. *Bambiraptor*. However, these referrals were based on limited comparisons. The discovery of a nearly complete *Saurornitholestes* specimen from the Dinosaur Park Formation now allows for a reappraisal of their identifications.

Despite MOR 553S-7.30.91.274 being larger than the holotype of *Bambiraptor*, it is proportionally nearly identical to the holotype maxilla. Its identification as adult cranial material of *Bambiraptor* is further supported by a phylogenetic placement as the sister taxon of *Bambiraptor*.

However, the anatomy and phylogenetic placement of MOR 660, MOR 721, and MOR 9753 do not support referral to *Saurornitholestes*.

MOR 660 is robust and differentiated by ilium morphology and characters on the cervical vertebrae, manual unguals, and metatarsals. Its placement in two different phylogenetic analyses indicates that it is a derived eudromaeosaur with possible affinities to the Saurornitholestinae, but it lacks a confident sister-taxon relationship with *Saurornitholestes* itself. MOR 660 is regarded as a new genus and species. MOR 9753 is a small partial maxilla with a squared-off antorbital fenestra, a straight ventral margin, an antorbital fossa ventrally bounded by a lip, and a large, dorsoventrally extended maxillary fenestra divided by a subhorizontal bar. Phylogenetic analysis supports a microraptorine placement, and MOR 9753 is regarded as a second new genus and species and the first North American microraptorine known from cranial material. MOR 721 is extremely gracile and is recovered in a phylogenetic analysis as a eudromaeosaur but is differentiated from MOR 660 by characters of the manual unguals and metatarsals and is distinguished from *Sauronitholestes* and *Bambiraptor* by pelvic characters. MOR 721 is thus considered to represent a third undescribed taxon from the TMF.

These re-evaluations indicate a previously unrecognized diversity of dromaeosaurid taxa from the TMF and emphasizes the growing picture of high dromaeosaurid diversity in Laramidia and Central Asia.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**A CRANIUM OF *CHRIACUS BALDWINI* (MAMMALIA, ARCTOCYONIDAE) FROM THE PALEOCENE OF NEW MEXICO, USA, AND THE PHYLOGENETIC POSITION OF *CHRIACUS***

Holbrook, Luke T.[1], Chester, Stephen G.[2]

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The genus *Chriacus* is an archaic “ungulate” known from the Paleocene and early Eocene of North America. *Chriacus* has historically been placed in the Arctocyonidae, but other workers have allied it with Pleuraspidotheriidae or considered it to be ancestral to Artiodactyla. Arctocyonidae is generally considered to be a heterogeneous, paraphyletic group of archaic “ungulates,” and differences in size and morphology between the smaller *Chriacus* and the larger *Arctocyon*, for example, support this view. The anatomy of *Chriacus* is relatively well known, due in large part to postcrania associated with teeth and even partial articulated skeletons. However, the cranial anatomy of *Chriacus* is not well known. We describe here the most complete cranium referred to *Chriacus baldwini* collected from the Paleocene of the San Juan Basin in New Mexico. While weathering and breakage limit interpretations, the specimen preserves much of the braincase and skull roof, as well as parts of the basicranium, including the petrosals. Recent studies of the endocast and internal structure of the ear of this specimen interpret *Chriacus* as being more reliant on olfaction than vision and having low to moderate agility. As these studies noted for its brain, the skull of *Chriacus* exhibits mainly plesiomorphic features for placental mammals. Including information from the new cranium, we added *Chriacus* to a matrix of 326 characters scored for 77 taxa, including a wide range of placental mammals, emphasizing various ungulates and including two species of *Arctocyon* and two pleuraspidotheres. Maximum parsimony analysis, both with and without topological constraints reflecting the four major placental clades identified in molecular studies, recovered 464 most parsimonious trees (MPTs) with constraints and 1140 MPTs without constraints. In both analyses the strict consensus is poorly resolved. While none of the MPTs in the unconstrained analysis unite *Chriacus* with *Arctocyon*, 88% of the MPTs in the constrained analysis recovered a *Chriacus*-*Arctocyon* clade. The position of *Chriacus* is still not fully resolved, but new data from fossils like the cranium described here have the potential to provide new insight into the relationship of *Chriacus* to other placentals.

**Funding Sources** Support for this research was provided by the U.S. National Science Foundation award number DEB 1456826.

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Virtual Posters

**A NEW PHYLOGENETIC PROPOSAL OF THE PTERANODONTOIDEA WITH SPECIAL FOCUS ON THE PTERANODOTIA AND A**

**MORPHOMETRIC ANALYSIS OF THE NYCTOSAURIDAE**

Holgado, Borja

Biological Sciences, Universidade Regional do Cariri, Crato, CE, Brazil

Pteranodontoidea is an ornithocheroid clade with a significant degree of consensus within the different phylogenetic hypotheses on pterosaur phylogeny. Pteranodontoids are pterodactyloid pterosaurs characterized by a constricted mid-shaft of their humeri, a subtriangular to trapezoidal distal articulation of their humeri, and distal syncarpalia with a triangular shape, among other common synapomorphies in different phylogenetic hypotheses. A relevant symplesiomorphic character of high consensus within the different hypotheses is the deltopectoral crest of their humeri distally warped, which is distinct in nyctosaurids, a relevant group of pteranodontoids with a characteristic hatched-shape deltopectoral crest of the humerus. The clade Nyctosauridae and relatives have recently been discussed in some phylogenetic works, but there is neither taxonomic nor systematic consensus, with dissenting results and even terminologies. In this work is presented a new phylogenetic analysis focusing in the clade Pteranodontia (within Pteranodontoidea), but also a morphometric clustering analysis on the diagnostic humeri of all species ever suggested within Nyctosauridae, including several non-type specimens. As a results, the clades Nyctosauridae, Pteranodontoidea, Pteranodontia, and Pteranodontidae ought to be visibly sustained as expected, but problematic taxa as *Cretornis hlavaci* or the recently published *Epapatelo otyikokolo* are recovered in a sister clade of the Pteranodontoidea, whilst *Alamodactylus byrdi* is recovered in a trichotomy together with Lanceodontia and Pteranodontia. However, the three aforementioned taxa are poorly known due to their limited appendicular material. The phylogenetic relationships within Nyctosauridae, a lineage at least present in Africa and both Americas, are still cloudy due to the limited material of some taxa (specifically, '*Nyctosaurus' lamegoi*, *Nyctosaurus nanus*, and *Simurghia robusta*) but the morphometric analysis shed light on a purported overrepresentation of nyctosaurid taxa from the Ouled Abdoun Basin (Morocco). In addition to this, as the first phylogenetic term proposed, Nyctosauridae includes all nyctosaurid-like taxa, being useless other recent terms proposed.

**Funding Sources** CERCA Programme/Generalitat de Catalunya (Spain) and the Brazilian research foundation FUNCAP (project #PV1-0187-00054.01.00/21) are acknowledged for their support.

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Technical Session 7: Birds (Thursday, October 19, 2023, 8:00 AM)

**AVIAN CRANIAL KINESIS IS THE RESULT OF INCREASED ENCEPHALIZATION DURING THE ORIGIN OF BIRDS**

Holliday, Casey[1], Wilken, Alec[2], Sellers, Kaleb[2], Witmer, Lawrence M.[3], Middleton, Kevin[1]

[1]University of Missouri, Columbia, Missouri, United States, [2]University of Chicago, Chicago, Illinois, United States, [3]Ohio University, Athens, Ohio, United States

The evolution of the avian skull from that of non-avian theropod dinosaurs involved dramatic increases in brain size but also significant biomechanical modifications in the feeding apparatus resulting in a segmented palate and the origin of powered prokinesis in neognath birds. Powered kinesis is considered in part responsible for the trophic diversity and success of birds, but how changes in neuroanatomy impacted the jaw muscles and cranial joints of the feeding apparatus remains unclear. Using an integrated approach of 3D reconstructions of skull morphology, jaw muscle modeling, and linkage analysis, we quantified the changes in muscle forces and their influences on the palate across the theropod transition to birds. We show the expansion of the neurocranium during non-avian theropod evolution reoriented the primitively mediolaterally-diagonal orientations of jaw muscles into more rostrocaudally-oriented positions in birds. These phenotypic transformations resulted in increased muscle force transmission through the pterygoid, enabling the propensity for powered cranial kinesis. Only after these loading conditions were in place did the breakdown of kinematic linkages occur, releasing the avian skull to possess their characteristic cranial kinesis. These findings illustrate the coordinated evolution of the neurosensory and feeding systems during the origin of birds and provide a new approach to identifying cranial kinesis in extinct vertebrate species.

**Funding Sources** NSF IOS 1457319, NSF EAR 1631684, NSF IOS 520100

Paleontological Management Poster Session
(Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**RE-PREPARATION AND PRESERVATION REVEALS NEW INSIGHTS INTO A UNIQUE SAUROPOD BONEBED (MORRISON FM, COMANCHE NATIONAL GRASSLAND, COLORADO)**

Hopkins, Joseph[1], Price, Madison G.[1], Toth, Natalie[1], Bastien, Salvador[1], Petermann, Holger[1], Schumacher, Bruce[2]

[1]Denver Museum of Nature & Science, Denver, Colorado, United States, [2]Washington Office, Lands and Minerals, United States Forest Service, Lakewood, Colorado, United States

Long-term preservation can be easily forgotten when it comes to paleontology collections, inhibiting the longevity and research value of fossil specimens. The Last Chance dinosaur quarry from the upper Morrison Formation of Southeastern Colorado was active from 2004-2008. Material recovered includes at least three partially articulated sauropod individuals initially identified as *Apatosaurus* and *Camarasaurus* along with many shed theropod teeth. The accretionary fluvial deposit boasts a unique narrative, hosting taphonomic conditions permitting pre-burial decay and predatory scavenging. After initial preparation, the fossils lay dormant for more than a decade allowing the onset of deterioration and disorganization. Efforts to further stabilize, restore, and re-house these fossils led to new understandings of the taxa represented at this locality.

Preliminary review suggests that taxonomic diversity may have been underestimated. When advances in the scientific understanding of Morrison paleofauna in the last decade are taken into consideration, cervical and dorsal vertebrae morphology provides evidence for additional sauropod taxa, particularly with respect to a juvenile individual. To ensure preservation of fossil bones and contextual data, a digital inventory was created using field notes including detailed quarry maps from the USFS and discussions with DMNS volunteers who helped collect the specimens. Large fossil bones separated during excavation efforts were fully reassembled with adhesives and stabilized using consolidants and placed into newly constructed archival cradles. The primary goal was to re-prepare and house the Last Chance specimens to the highest professional standards because we are stewards who strive continually to enhance conservation conditions of stored collections. These improvements make the collection more accessible for research purposes, and better stabilized for handling in subsequent years (considerations especially important for large and heavy sauropod bones). Long term goals include digital scanning of skeletal elements, making them accessible to researchers globally via online 3D models. Utilizing a workforce of citizen-science volunteers and students for excavation and preparation efforts, this project highlights a fundamental mandate of the Paleontological Resources Preservation Act to "emphasize collaborative efforts with non-Federal partners, the scientific community, and the general public."

**Funding Sources** United States Forest Service

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Technical Session 2: Early Mammals & Carnivora
(Wednesday, October 18, 2023, 8:00 AM)

**REEVALUATION OF THE ECOLOGICAL NICHE OF THE LATE PLEISTOCENE FELID *MIRACINONYX TRUMANI***

Hotchner, Anthony, Meachen, Julie

Anatomy, Des Moines University, West Des Moines, Iowa, United States

*Miracinonyx trumani* was a species in the family Felidae that lived during the late Pleistocene across North America. It has been called the 'American Cheetah' due to its morphological similarities with the African cheetah *Acinonyx jubatus*, and because of those similarities it has been thought to be primarily a cursorial animal. Previous studies have questioned if *M. trumani* was truly cursorial like *A. jubatus*, or was more adapted to pursuit in uneven, rocky terrain like the snow leopard, *Panthera uncia*. For this study we compared the postcrania of *M. trumani to P. uncia* and other large felids to determine if this hypothesis was supported by the morphology. We completed this study to better understand the ecological role of the American cheetah in the Pleistocene ecosystem. We analyzed the long bones of *M. trumani, Puma concolor, A. jubatus, P. uncia, & Panthera leo* using 3D models. Our results show a grade of traits that coincides with locomotor abilities ranging from cursorial, as in *A. jubatus*, to scansorial, as in *P. concolor*. *M. trumani* has a morphology most similar to that of *P. leo*. These results do not lend support to previous hypotheses of a purely cursorial or 'snow leopard-like' *M. trumani* but instead paint a picture of a cat that had a mosaic mode of locomotion with the ability for speed, but it was not as specialized as the cheetah. Additionally, our results suggest that unlike the cheetah, *M. trumani* retained the ability to grapple prey like *P. concolor* or the pantherines. This more holistic image of *M. trumani* gives us a better idea of the way that it hunted its prey and its locomotor specializations (or lack thereof).

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Virtual Posters

**FIRST POTENTIAL RECORD OF "TERROR BIRD" FROM THE PALEOGENE OF NORTH AMERICA (AVES: CARIAMIFORMES: PHORUSRHACIDAE)**

Houde, Peter

Biology, New Mexico State University, Las Cruces, New Mexico, United States

"Terror birds" were apex predators throughout most of the Cenozoic of South America. I report a flightless predatory bird from the Ypresian (Wa-2 NALMA), Early Eocene, Willwood Formation, Clarks Fork Basin, north central Wyoming, USA. It is comprised of a raptorial premaxilla, complete wing, quadrate, and pedal phalanges. The entire bird skeleton collection of the Smithsonian Institution was examined for first-order comparison. The fossil is recovered within Phorusrhacidae in a preliminary cladistic analysis (wing characters of Degrange et al 2015), although no single character uniquely diagnoses Phorusrhacidae. It most closely resembles psilopterine phorusrhacids, but differs from them in some details, e.g., non-pneumatic humerus. If correctly identified, then it is the only record of Phorusrhacidae from North America preceding the Great American Biotic Interchange. Like many or most phorusrhacids, the fossil bird appears to have been flightless. It groups outside of the range of volant birds in a ternary plot of intramembral bone lengths, and it shares morphological characters known otherwise only in flightless birds. Wing characters associated with flightlessness in unrelated birds raise the possibility of convergence, hence phylogenetic inference. Pronounced muscle insertions and impressions for the attachment of remiges on the ulna suggest other potential uses of the wings, such as intraspecific combat and agonistic display as in some other flightless birds. If indeed a flightless phorusrhacid, then the biogeography of the fossil is provocative because phylogenomic timetree analyses date the origin of Cariamiformes to the late Paleocene when North and South America were ostensibly isolated from one another.

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Preparators' Session (Thursday, October 19, 2023, 8:00 AM)

**THE IMPACT OF ADHESIVES, CONSOLIDANTS, AND SOLVENTS ON GEOCHEMICAL DATA: AN EXAMPLE USING X-RAY FLUORESCENCE**

Householder, Mindy[1], Boyd, Clint A.[2]

[1]State Historical Society of North Dakota, Bismarck, North Dakota, United States, [2]Paleontological Resource Protection, North Dakota Geological Survey, Bismarck, North Dakota, United States

Adhesives are an integral part of the preparation process. They are necessary for the stabilization of fossils both in the field and in the laboratory and their use is ubiquitous in paleontology. However, the effect that applying these chemicals may have on future geochemical studies remains largely unstudied. To explore this question, we conducted a series of tests on commonly used adhesives using a Niton XL5 pXRF spectrometer. First, we scanned beads of Paraloid B72, Butvar B76, and Butvar B98 to determine if their actual elemental composition matched their published chemical formulae. Those adhesives were then mixed with acetone, allowed to dry in a circular disk at the bottom of plastic bottles (both LDPE and HDPE), and scanned to determine if any additional contaminants were introduced by either the solvent or the bottles. Additionally, the inner surfaces of the bottles were scanned before and after the above-mentioned adhesives and solvents were added and allowed to dry to determine if the elemental composition of the bottles was altered, which in turn would impact the composition of the adhesives stored in such bottles. The final test aimed to determine if and to what degree the presence of adhesives impacts the full spectrum of elemental data obtained from scans of matrix samples. For that test, five hand samples of non-fossil bearing sandstone were scanned before and after (in the same spot) the application of either Paraloid B72 or Butvar B76 (both in acetone) of various thicknesses. Briefly summarized, the results show that all three adhesives contain trace amounts of unreported elements (e.g., Si, Al, K, S) and that the solvents/adhesives do leach some elements from the plastic bottles (e.g., Si, K, Cl, S, Ti), changing the chemical composition of the dried adhesive. The matrix tests showed a clear

decrease in most detectable elements that was proportional to the thickness of the adhesive applied. However, the effect was not uniform as some elements (e.g., Si, Al, Mg, and P) were more strongly affected than others. The only element that showed increasing values with glue thickness was Cl, which resulted from contamination from the bottles/solvents. Though limited in scope, this study demonstrates that adhesives can both interfere with the collection of data from a pXRF spectrometer and introduce contamination to those data. A broader study is planned to evaluate a wider range of modern and historical adhesives, consolidants, and solvents.

**Funding Sources** This research was funded by the David B. Jones Foundation.

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**NEW EARLY TORREJONIAN (TO1) MAMMALS FROM NORTHEASTERN MONTANA, U.S.A.**

Hovatter, Brody T.[1], Wilson Mantilla, Gregory[2]

[1]Department of Earth and Space Sciences, University of Washington, Seattle, Washington, United States, [2]Department of Biology, University of Washington, Seattle, Washington, United States

The Western Interior of North America documents the most complete record of Paleocene mammal evolution following the Cretaceous/Paleogene (K/Pg) mass extinction event (Puercan through Clarkforkian North American Land Mammal ‘ages’ [NALMAs]). Although the broad strokes of mammalian recovery and radiation in the early Cenozoic have been well established, the more granular patterns of their diversification are hampered by the uneven distribution and sampling of fossiliferous deposits across time and space. One particularly poorly known time interval is the early Torrejonian (To1) NALMA; localities considered To1 in age are currently recognized from the Fort Union Formation in Montana, the North Horn Formation in Utah, and the Nacimiento Formation in New Mexico, but these sites have yielded far fewer mammal fossils compared to older Puercan and younger Torrejonian localities in those regions.

Here we report a new assemblage of mammal dental fossils recovered from the To1 Farrand Channel and Horsethief Canyon localities from the Tullock Member of the Fort Union Formation in northeastern Montana. These new fossils document as many as 51 species and include an array of multituberculates, cimolestids, leptictids, plesiadapiforms, archaic ungulates, and triisodontids, several of which represent new occurrences at these localities and likely more than one new species. These new discoveries help clarify the age of the Farrand Channel and Horsethief Canyon localities, which chronostratigraphic data suggest may be the oldest and most northerly To1 local faunas presently known; they also allow for more complete comparisons with local faunas similar in age elsewhere in the Western Interior and contribute to our understanding of biogeographic provincialism in the early Paleocene. Further, we characterize the composition of this assemblage and evaluate changes in mammal taxonomic diversity through the local faunal succession. Our results reveal that multituberculate species richness slightly decreased and relative abundance drastically declined relative to late Puercan local faunas in the region, whereas archaic ungulates and plesiadapiform primates both continued a pattern of increasing species richness and relative abundance, although along different trajectories. Taken together, our results contribute to the poorly known To1 record and help more precisely elucidate changes in local mammal communities following the recovery of mammals after the K/Pg mass extinction.

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Romer Prize Session (Thursday, October 19, 2023, 8:00 AM)

**DIGGING DEEPER INTO SNAKE ORIGINS: BODY SIZE EVOLUTION AND ECOMORPHOLOGICAL CORRELATES TO FOSSORIALITY PROVIDE NEW DATA ON THE ECOLOGICAL ORIGINS OF SNAKES**

Howard, Alexandra

Zoology, University of Cambridge, Cambridge, United Kingdom

Hypotheses of snake origins have primarily focused on the dichotomy between two competing ancestral ecological scenarios: aquatic or fossorial. Evidence for either of these hypotheses has traditionally relied on morphological interpretations of snake clades and the inferred relatedness of Cretaceous snakes to extant clades. However, recent advances in technology and analytical techniques allow investigation of the origin of clades from novel perspectives. Here I examine the ecological origin of snakes by looking at how morphology interacts with body size and ecology in the context of published phylogenetic topologies constructed with molecular data. First I examine body size evolution across snakes, using a combination of ancestral state reconstructions, body size estimates of fossils from regression models, and evolutionary rate modelling of alternate hypotheses of fossil snake phylogenetic relationships. Using these methods, I find that ancestral state reconstructions correlate better with body size estimates of fossil snakes when Cretaceous snakes such as madtsoiids are interpreted as total clade Alethinophidia, as opposed to stem snakes. Secondly, I examine how body size diversity affects morphology by investigating cranial anatomy in a comparative context in a clade of miniaturized snakes, the Typhlopidae (Serpentes: Scolecophidia). I identify previously unappreciated morphological variability in this clade that forces reinterpretation of characters previously used to support traditional morphological topologies within Alethinophidia. Finally, I examine how the morphology of the skull roof in snakes correlates with a fossorial ecology in extant snakes using geometric morphometrics, and test competing hypotheses for the ecology of the Cretaceous stem snake *Dinilysia patagonica*. I identify a distinct morphological gradient associated with terrestrial to fossorial ecology and predict that *Dinilysia* likely had fossorial habits. Together, my projects support the hypothesis that the early evolution of snakes was influenced multiple adaptations to fossorial ecologies. My projects also demonstrate how integrative research using both extant and paleontological data can elucidate questions about the early evolution of clades, particularly the heavily debated ecological origin of snakes.

**Funding Sources** Trinity Hall Postgraduate Research Studentship. Research was supported by Natural Environment Research Council grants NE/W007576/1 and NE/ S000739/1

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Technical Session 6: Marine Reptiles (Wednesday, October 18, 2023, 1:45 PM)

### A NEW PACHYPLEUROSAUR (REPTILIA: SAUROPTERYGIA) FROM THE MIDDLE TRIASSIC OF SOUTHWESTERN CHINA

Hu, Yi-Wei, Li, Qiang, Liu, Jun

Hefei University of Technology, Hefei, Anhui, China

After the devastating Permo-Triassic Mass Extinction, several new groups of large predators invaded the sea in the early part of the Triassic, including sauropterygians, ichthyosauromorphs and thalattosaurs. Among these predators, sauropterygians are the most abundant group in terms of the generic/species diversity. Here we report a new species of Pachypleurosauria (Sauropterygia: Eoauropterygia) from a recently discovered Lagerstätten in the upper member of Anisian Guanling Formation. The only known specimen of the new species was collected from Muta village, Luxi County, Yunnan Province, South China. Our new phylogenetic analysis based on a novel data matrix recovered the new taxon as a sister group to *Dianmeisaurus*. The new phylogenetic analysis also collapsed the monophyly of traditionally recognized Eusauropterygia. Pistosauridea, *Majiashanosaurus*, and *Hanosaurus* comprise the consecutive sister groups to a new clade including Pachypleurosauria and Nothosauroidea. A monophyletic Pachypleurosauria, of which the clade consisting of *Dianmeisaurus* and *Panzhousaurus* occupy the basal-most position, is recovered by this study. The clade consisting of *Dawazisaurus* and *Dianopachysaurus* forms the sister group to remaining pachypleurosaurs included in this study. Since *Dianmeisaurus*, *Panzhousaurus*, *Dawazisaurus* and *Dianopachysaurus* are all exclusively known from South China, we suggest that pachypleurosaurs had a paleobiogeographic origin in the eastern Tethys.

**Funding Sources** This work was supported by the National Natural Science Foundation of China (Grant numbers 42172026 and 41772003).

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Technical Session 12: Methods & Paleohistology (Friday, October 20, 2023, 8:00 AM)

### STATE SPACE MISSPECIFICATION IN LIKELIHOOD-BASED PHYLOGENETIC ANALYSIS OF MORPHOLOGY AND ITS IMPACT ON TREE TOPOLOGY

Huang, EJ, Bever, Gabriel S.

Johns Hopkins University, Baltimore, Maryland, United States

The inherent complexity of morphological systems represents a significant challenge for modeling evolutionary dynamics in a realistic way and for fully incorporating fossils into probability-based analyses.

Unlike nucleotide and amino acid sequences that involve a fixed number of possible biomolecules, the required threshold of variation to qualify as a new state within a morphological character system is often subjective, and many discretized characters are fundamentally continuous. Such practice has minor effect on parsimony analysis given its only impact is information loss. However, for likelihood-based analysis, including maximum likelihood and Bayesian inference, specification of state space has a number of important downstream effects. Likelihood calculation in both cases relies on transitional probability, which is influenced by the size of the state space. Unfortunately, the true state space of any morphological characters is unknown. The oft-employed solution to this problem is deeply unsatisfying as it simply involves applying a single substitution model to all morphological characters. These considerations suggest that state space misspecification is a common phenomenon in morphology-based studies, although the practical implications of this theoretical stance are far from clear.

In this study, we investigate the impact of state space misspecification using both simulated and empirical data, testing the null hypothesis that the phylogenetic impacts are negligible. Results from tree and character simulations show that incorrect state space leads to greater disparity between the true and reconstructed tree, with the phylogenetic error increasing with the gap separating the true and assumed state space. Impacts on tree topology are even more apparent with empirical data, likely due to data incompleteness and the complexity that often governs the genotype-phenotype map. Clades enjoying moderate bootstrap support are not immune to these effects. Even when tree topology is unaltered, branch lengths can vary significantly. The implications of these findings for paleontology are numerous and certainly extend to one of the primary roles fossils assume in synthetic evolutionary studies in serving as the primary source for tree dating. The incomplete nature of fossils makes paleontology particularly vulnerable to state space misspecification and the major effects on inference accuracy and precision that can stem from minor changes in tree topology.

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**MICRO-COMPUTED TOMOGRAPHY CASTS NEW LIGHT ON THE PROCESS OF PTERYGOID SEGMENTATION IN THE PALATES OF JUVENILE NEOGNATHOUS BIRDS.**

Hunt, Annabel K., Plateau, Olivia, Benito, Juan, Fisher, Louis, Field, Daniel J.

Earth Sciences, University of Cambridge, Cambridge, Cambridgeshire, United Kingdom

Recent descriptions of neognathous-like bony palate elements in the stem-birds *Ichthyornis* and *Janavis* have challenged long-held assumptions about the origin of the modern bird palate. Until recently, it was widely accepted that the fused condition epitomised by the ‘palaeognathous palate’ represented the ancestral condition for crown birds. Given this shift in our understanding of avian palate morphology, a re-assessment of the developmental underpinnings of crown bird palate anatomy is warranted. Here we examine the morphologies of the palatine and pterygoid in embryonic and early post-hatchling neognaths. We investigate the process of pterygoid segmentation—the process whereby the rostral portion of the pterygoid separates into a so-called ‘hemipterygoid’ and fuses with the palatine during neognath ontogeny. Pterygoid segmentation was first described over 100 years ago and despite frequent references to this process in the literature, the phenomenon remains poorly understood. Explanations for this uncertainty most likely stem from difficulties associated with interpreting the 3D interrelationships of bones from line drawings and photographs. Therefore, in this study we use micro-computed tomography to elucidate the 3D morphologies and interrelationships of bones involved in the segmentation process—the pterygoid, palatine and hemipterygoid. Our results help clarify the apparent absence of a hemipterygoid in Galloanserae and more broadly help document the evolutionary history of pterygoid segmentation among crown birds.

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**CONTRASTING BODY SIZE EVOLUTION IN ENTOPTYCHINE AND GEOMYINE GOPHERS (RODENTIA, GEOMYIDAE)**

Hunt, Molly E.[1], Ball, Madeline P.[2], Claxton, Alexander[3], Martin, Robert A.[4], Jimenez-Hidalgo, Eduardo[5], Calède, Jonathan J.[2]

[1]Ohio Geological Survey, Columbus, Ohio, United States, [2]The Ohio State University, Columbus, Ohio, United States, [3]Oklahoma State University, Stillwater, Oklahoma, United States, [4]Murray State University, Murray, Kentucky, United States, [5]Universidad del Mar, Laboratorio de Paleobiología, Oaxaca, Mexico

Pocket gophers (family Geomyidae) are the dominant burrowing rodents in North America today. They are also one of the most species-rich groups present during the rodent diversification of the Oligocene in North America, around 30 million years ago. To understand the taxonomic radiation of gophers, we seek to take an ecological approach and document changes in ecomorphology that may explain diversification.

Body size is a critical property of animals associated with many ecological and life history characteristics, notably locomotion and habitat. In this study, we explore body size evolution to constrain the processes at play in the radiation of geomyid rodents during the Oligocene when an extinct subfamily, the Entoptychinae, were diversifying as well as during the Pliocene, when the extant subfamily Geomyinae diversified. Pocket gophers are the last important Oligocene-aged rodent groups whose body size is yet to be analyzed. Therefore, we started our work with an analysis of the correlation between body mass and various measures of the skull and teeth (skull length, upper and lower toothrow lengths, and lower p4 length) to determine the best proxies for body size in geomyoid rodents. We find that the toothrow lengths are the most accurate predictors. We therefore used toothrow lengths from 286 fossil specimens and body mass data for 61 species from museum collections and the literature as well as a phylogenetic framework for both geomyines and entoptychines to explore the mode of evolution of body size in the two groups of rodents. Our results show that the evolution of body size in Entoptychinae follows an Ornstein Uhlenbeck model whereas body size evolution within Geomyinae follows a directional model. Within Entoptychinae, the ancestral body mass was intermediate and small body size evolved at least three times across three different genera; species found in Mexico and west of the Rocky Mountains are larger than those from the Great Plains. Within Geomyinae, the genus *Thomomys* remained small whereas several genera (e.g., *Heterogeomys, Zygogeomys*) independently evolved large sizes. Future analyses integrating this work with diversification rates will help uncover any possible link between ecomorphological evolution and evolutionary radiation in pocket gophers.

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Technical Session 10: Euarchontoglires & Xenarthra (Friday, October 20, 2023, 8:00 AM)

**CROWN TYPES REVISITED: PATTERNS OF PHENOTYPIC DIVERSITY IN THE LOWER DENTITION OF PALEOGENE PRIMATES AND PLESIADAPIFORMS**

Hunter, John P.[1], Schottenstein, Naava[2], Jernvall, Jukka[3]

[1]Department of Evolution, Ecology, and Organismal Biology and School of Earth Sciences, The Ohio State University, Newark, Ohio, United States, [2]Department of Biological and Physical Sciences, Columbus State Community College, Columbus, Ohio, United States, [3]Institute of Biotechnology and Department of Geosciences and Geography, University of Helsinki, Helsinki, Finland

Crown types -- based on the number, location, and shape of upper molar cusps and the orientation of crests or lophs – have revealed broadscale patterns in the diversity of teeth in extant mammals, trends in Cenozoic ungulates with the adoption and spread of herbivory, and ecological impacts of future primate extinctions. Recently, crown types have been less used than newer approaches of assessing dental shape and diversity that offer greater detail by relying on scanning technology or computed tomography. Nevertheless, crown typing retains certain advantages such as rapid classification of basic morphotypes, by which one can attain broad taxonomic and temporal sampling in a reasonable time. Here, we use crown types to study the first two evolutionary radiations of primates, the plesiadapiforms and euprimates in the Paleogene of North America, for the purpose of revealing ecological, evolutionary, and developmental inputs on dental diversity. Innovations of this study include adapting the crown typing scheme to the lower dentition and expanding the approach to premolars. These changes allow us to categorize the variety of lower premolars and molars that arose among early primates, which likely played a key role in their dietary adaptation. We also take advantage of the natural division of lower cheek teeth into a trigonid and a lower (i.e., later developing) talonid to test evolutionary hypotheses arising from differences in developmental timing. Crown type diversity (number of crown types) is related to species sampling in our data, but disparity (total range and average city block distance) is more independent. Disparity through p3-m2 is generally uniform, apart from the trigonid of p4, which exhibited exceptionally high disparity levels due to the multi-cusped, bladed premolars of carpolestid plesiadapiforms. In p3, the number of talonid crown types outnumber trigonid crown types by more than double. In p4-m2, the number of trigonid and talonid crown types are similar, but species distributions differ. Trigonids tend to be dominated by one crown type, whereas talonids tend to have a more even distribution of species across several. In molars, crown type complexity (sum of the crown type variables) has a central tendency of 6-7 at small body size that decreases through the size range to 5-6. This loss of complexity with size reflects the evolutionary reduction of cusps (e.g., the paraconid) in lineages of primates adapted to more frugivorous diets.

**Funding Sources** Ohio State University provided support through an Alumni Grant for Graduate Research and Scholarship to N Schottenstein and Professional Development Funds to J Hunter.

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Paleontological Management Poster Session
(Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**CAN YOU HEAR ME NOW? HAVING YOUR VOICE HEARD ON PALEONTOLOGICAL ISSUES THROUGH PUBLIC COMMENT PERIODS**

Hunt-Foster, ReBecca K.[1], Breithaupt, Brent H.[2]

[1]Dinosaur National Monument, Jensen, Utah, United States, [2]Wyoming State Office, Bureau of Land Management, Cheyenne, Wyoming, United States

In Federal agencies most land-use and environmental plans are reviewed under the National Environmental Policy Act (NEPA). These reviews require the consideration of environmental effects in Federal informed decision making, often through the creation of detailed Environmental Impact Statements (EIS), or more straightforward Environmental Assessments (EA). This process must be completed before an agency can make a final decision on a proposed action and is required for Federal decision makers to be knowledgeable of the environmental impacts of their decisions. These projects and plans are listed online via the Bureau of Land Management's (BLM) National NEPA Register, "e-Planning", or on the National Park Service's Planning, Environment and Public Comment (PEPC) site. These sites allow the public to access, review, and comment on projects. While these comments are not a vote on whether a proposed action should take place, the information provided by the public can help influence Federal land managers on their final decisions. Individuals can participate by working with other interested parties or by working through State, Tribal, or local government. In paleontology, proposed projects may directly or indirectly relate to fossil resources. These could include Federal construction projects, Federal endorsements of non-Federal activities such as grants, licenses, and permits, or plans to manage and develop federally owned lands. Examples of past projects could be as apparent as a fossil excavation or site development or as ambiguous as road, waterline, or transmission line impacts to fossil resources. Public involvement is necessary to assist the Federal government in making informed, scientific-based management decisions; often in situations where fossil resources are unacknowledged in the NEPA process or overlooked due to the lack of informed federal staffing at local levels where the actions are taking place on the ground. While upper-level federal paleontologists may be asked to review an EIS, they may be unaware or unable to check the thousands of EA's that go through the Federal system each year. The public comment process requires a commitment of time and willingness to share information between the relevant agency and citizens to help better manage and protect paleontological resources using scientific principles and expertise.

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Paleontological Management Poster Session
(Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**PROACTIVELY INCREASING PUBLIC AWARENESS ABOUT THE SIGNIFICANCE OF PALEONTOOLOGICAL RESOURCES ALONG THE FOSSIL DISCOVERY TRAIL IN DINOSAUR NATIONAL MONUMENT**

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The Fossil Discovery Trail (FDT) is located in the Nielsen's Gulch drainage, immediately east of the Quarry Exhibit Hall (QEH) in the Utah portion of Dinosaur National Monument (DINO). This 1.2-mile (2 km) trail cuts through the extensive uptilted rock units exposed in this area, including the Jurassic Stump and Morrison formations, and the Cretaceous Cedar Mountain, Muddy, Mowry, Frontier and Mancos formations. This trail was created as a place for visitors to view fossils in situ during the temporary closure and reconstruction of the QEH in the mid to late 2000's and has remained the most frequently hiked trail in the Monument. Stops in the Stump, Morrison, and Mowry formations highlight invertebrate and vertebrate fossils. The Morrison Wall Spur provides the opportunity for visitors to view and visit a variety of vertebrate fossils in their natural state, just as Earl Douglass discovered them in 1909. This stop parallels the "Quarry Sandstone" which is the same unit that can be seen directly to the west in the QEH and the historic Carnegie Quarry. While the Carnegie Museum did collect some specimens from the Quarry Sandstone in Nielsen's Gulch, the majority of the fossils here remain in place, and were included in the original 80 acres designation of DINO in 1915.

Managing in situ fossil resources is not without its challenges. This trail area contains the greatest number of paleontological resource incidents, going back to the discovery of the Carnegie Quarry. Incidents range from rock collecting and the creation of unofficial "social trails", to unpermitted excavations and the theft of large dinosaur bones, most notably the damage and theft to a sauropod humerus in 2014. While initial documentation of the FDT Morrison Spur Wall took place in the early 2010's, an in-depth survey and status has not taken place since 2015. In the summer of 2023, this program was expanded to include this baseline data by mapping exposed fossils in the sandstone along this section. These data have been made available to DINO interpretation and law enforcement staff for use when fossils at this site are suspected of having been damaged, vandalized, or stolen. This work has also proactively provided the opportunity to directly discuss the fossil resources and their protection with visitors using scientific principles and expertise, allowing for an increase in public awareness about the significance of paleontological resources.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**TAPHONOMIC AND RARE EARTH ELEMENT ANALYSIS OF HADROSAUR FEMUR FROM PALEOCENE ROCKS IN THE SAN JUAN BASIN, NEW MEXICO**

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There are no broadly accepted examples of non-avian dinosaurs surviving into the Paleocene after the Chicxulub impactor hit the Gulf of Mexico. However, a large hadrosaur femur found in 1983 in the early Paleocene Ojo Alamo Formation in the San Juan Basin of New Mexico (NMMNH P-91647) has been asserted to represent such a circumstance, although its interpretation has been the subject of extensive debate in the literature. Were this femur to represent a Paleocene non-avian dinosaur so close to the impact location, this would necessitate a reinterpretation of the nature and mechanics of the extinction-causing impact. Alternatively, the bone could represent a Cretaceous dinosaur that died and whose femur was reworked into younger sediments. A recent renovation of the museum in which the femur was displayed opened the opportunity for more detailed scientific study of the specimen. We reexamined the femur and nearby sediment samples using modern geochemical and photogrammetric analyses in order to reassess its taxonomic affiliations and its taphonomic history.

The presence of muscle scarring on the craniodistal portion of shaft just above lateral condyle indicates that it belongs to a lambeosaurine hadrosaurid. The only known lambeosaurine of sufficient size from New Mexico is *Parasaurolophus tubicen*, but the specimen cannot be conclusively identified to genus level. The femur was a lone, disarticulated specimen in a coarse channel deposit, suggesting a significant preburial taphonomic history. Fossil bones are, however, rare in the Ojo Alamo. Photogrammetrically assessed patterns of surface modification are also indicative of an extended taphonomic history with scratching and abrasion formed by extended interaction with moving sediment. ICPMS REE analysis of the bone and nearby sediment samples will test for the presence of a Cretaceous geochemical taphonomic fingerprint alongside subsequent Paleocene-Recent overprinting. Thin-sectioning of infilled fractures in the femur will provide another test of the Cretaceous provenance of the bone, should non-Ojo Alamo sediments be found in the depths of the fractures.

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Technical Session 9: Sauropsids (Thursday, October 19, 2023, 1:45 PM)

**DENTAL COMPLEXITY AND CONVERGENCE IN CARBONIFEROUS-PERMIAN REPTILES: NEW µCT EVIDENCE FROM *PUERCOSAURUS OBTUSIDENS***

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The Carboniferous-Permian Cutler Group of the Chama Basin, northern New Mexico, documents vertebrate faunas in early phases of the expansion of drylands. Although synapsids and diadectomorphs from the Chama Basin are well-documented, reptiles from this region are poorly-known. We address this by revisiting the morphology of *Puercosaurus obtusidens,* a small eureptile represented by the holotypic hemimandible and an unassociated partial skull. Previous revisions of this material using traditional methods were unable to identify diagnostic anatomy, leaving this species a nomen dubium. Using µCT, we fully describe this enigmatic form for the first time and revisit the validity of the taxon. *Puercosaurus* preserves a combination of plesiomorphic and apomorphic characters that suggest it is a unique early-diverging eureptile, distinct from the co-occurring Cutler captorhinid *Rhiodenticulatus*. The parietal is comparatively short, less than half the length of the frontal. Marginal teeth are compressed labio-lingually, rather than peg-shaped. Enlarged chisel-shaped maxillary teeth are present at mid row. The dentary bears 17 mesio-distal tooth positions in the holotype, and 17 or 18 in the referred specimen, slightly higher than the estimated number of 15 or 16 in *Rhiodenticulatus*. In both specimens of *Puercosaurus*, a second lingual row of marginal teeth is developed on the posterior portion of the dentary tooth row behind the enlarged "crushing" teeth. The second row is relatively short and likely represents local derivation of a tooth battery from laminar replacement of the dentition at the back of the row, as also reported in some parareptiles and recumbirostrans. The dentary is relatively straight and is triangular rather than rounded in cross-section (contra anatomically-derived captorhinids). Despite poor surface preservation of the referred specimen, dermal sculpturing on the holotypic mandible was apparently weak to absent compared to other captorhinids. *Puercosaurus* and similar records of multiple-tooth-rowed captorhinids represent a dietary diversification in small reptiles in the southwest by earliest Permian times. Our restudy of *Puercosaurus* further supports the emerging picture that maxillary and mandibular tooth batteries evolved at least three times in captorhinomorphs, as well as in parareptiles and recumbirostrans, suggesting the presence of a widespread ancestral developmental toolkit driving tooth battery formation in early amniotes.

**Funding Sources** National Science Foundation NSF-EAR-2219902

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Technical Session 3: Fishes & Amphibians (Wednesday, October 18, 2023, 8:00 AM)

**A PHYLOGENETIC RE-EXAMINATION OF LEPOSPONDYLII; IMPLICATIONS FOR CROWN TETRAPOD DIVERGENCE TIMES AND THE ORIGIN OF AMNIOTES**

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Lepospondyls are small-bodied, mostly aquatic Carboniferous and Permian tetrapods, and their phylogenetic interrelationships have been highly contested regarding their position relative to amniotes and amphibians. Lepospondyls have frequently been proposed as being key to the origin of all modern groups of lissamphibians, or on the stem of Gymnophiona with a polyphyletic Lissamphibia or being closer to the origin of amniotes (mammals, reptiles), with lissamphibians instead nested within Temnospondylii. Recent analyses have also questioned the monophyly of lepospondyls, placing groups such as the tiny, limbless aistopods on the tetrapod stem-lineage, and therefore not relevant to the origin of either amniotes or lissamphibians. Inconsistent results are, in part, due to the unstable phylogenetic position of the lepospondyl clade Microsauria, but microsaurs and other clades of lepospondyls have often been poorly taxonomically represented in these same analyses.

Here we present a novel phylogenetic analysis of early tetrapods, including substantial representation of lepospondyls and early amniotes as well as wide taxonomic representation of other early tetrapod groups, including stem taxa. We include 70 taxa and 340 characters, including new data on the enigmatic Carboniferous tetrapod *Westlothiana lizziae*, which has been considered both close to amniotes and close to lepospondyls. Our results contrast with other recent studies of tetrapod phylogeny; we demonstrate a monophyletic Lepospondylli with *Westlothiana* as the sister taxon to all other lepospondyls. We also recover microsaurs as a paraphyletic grade with respect to other lepospondyls. Our results support the traditional recognition of Lepospondyli as a monophyletic group, and as the sister taxon to amniotes. This topology extends the divergence of the major clades of crown tetrapods back into the early Carboniferous and suggests that the total-clades of amphibians and amniotes had evolved far earlier than previously thought.

**Funding Sources** Natural Environment Research Council (NERC) - UKRI

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Virtual Posters

### A NEW FOSSIL LIZARD WITH TRICUSPID TEETH FROM THE LOWER CRETACEOUS OHYAMASHIMO FORMATION OF THE SASAYAMA GROUP, HYOGO, JAPAN

Ikeda, Tadahiro, Ota, Hidetoshi, Tanaka, Tomonori

Institute of Natural and Environmental Sciences, University of Hyogo, Sanda, Hyogo, Japan

A fossil assemblage of vertebrates, comprising skeletal remains of ceratopsian dinosaurs, lizards, and mammals, had been unearthed from the Ohyamashimo Formation (Albian), Sasayama Group at the Miyada locality in Tambasasamaya City, Hyogo, Japan. Recent resurvey of the site has yielded additional squamate fossils including one nearly complete right dentary of an unidentified lizard. This dentary bears a total of 15 heterodont pleurodont teeth, of which the 5th to 11th (middle teeth) are tricuspid. The features clearly differentiate the present specimen from those previously described for lizard taxa from the Ohyamashimo Formation, such as *Morohasaurus kamitakii*, *Pachygenys adachii*, and four morphotypes of unnamed scincomorphans. Of the Mesozoic lizards, those from the Late Cretaceous sediments assigned to the Iguania and Borioteiioidea are known to commonly possess tricuspid teeth. With respect to lizards prior to the Late Cretaceous, however, very few taxa, such as *Ptilotodon wilsoni* from the Antlers Formation (Aptian-Albian) in the USA and *Asagaolacerta tricuspidens* from the Kuwajima Formation (Barremian) in Japan, exhibit such dental features. The examined specimen also exhibits an open Meckelian groove: Because the groove displays constriction in Iguania, the specimen most likely belongs to the borioteiioids. However, the absence of prominent cementum deposition around the tooth bases, a feature characteristic to many advanced borioteiioids, distinguishes this specimen from the derived members of the group. Furthermore, the examined specimen exhibits notable unique features, such as cylindrical tooth shafts with crowns of similar widths, middle teeth each with sharply pointed conscentral cusp and flanking anterior and posterior cuspules of heights similar to that of the former. These features are exclusively shared with *A. tricuspidens*, from which the specimen, however, differs in dentary shape. Further detailed comparative investigations are required to clarify the phylogenetic relationships and determine the taxonomic allocation of the present specimen with certainty. Our results suggest that the lizard fauna of the Ohyamashimo Formation includes taxa unique to this formation, besides those seemingly shared with other fossil microvertebrate communities in Japan and the continental China.

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

### NEW REPORT OF OSTEOSARCOMA IN A MULTI-INDIVIDUAL DINOSAUR ASSEMBLAGE AND ITS PALEOECOLOGICAL IMPLICATIONS

Inaba, Hayato[1], Matsumoto, Ryo[2], Chiba, Kentaro[2], Okoshi, Tsukasa[3], Takasaki, Ryuji[4], Murakami, Kaisei[3], Saneyoshi, Mototaka[2], Tsujigiwa, Hidetsugu[5], Mainbayar, Buuvei[6], Tsogtbaatar, Khishigjav[6]

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Paleopathological studies provide us with critical insights into the physiological and ecological aspects of extinct organisms. Recent studies incorporate modern medical criteria, developed extensively in human medical research, to diagnose the pathological origins of the lesions in fossil bones. A recent study on a ceratopsian dinosaur *Centrosaurus apertus* diagnosed the lesion of a pathological fibula as osteosarcoma with such an approach. Here we diagnosed another case of osteosarcoma in a dinosaur specimen surface collected in Bugin Tsav, the Gobi Desert, Mongolia, where the Upper Cretaceous Nemegt Formation is exposed. The material includes similarly-sized fragmented limb and pelvic elements and relatively complete pedal phalanges and unguals. The minimum number of individuals is two based on two left distal ends of the tibiae. The morphology of these elements indicates the specimens represent small theropods, likely oviraptorosaurs. The pathological lesion in question covers the distal portions of the right three metatarsals. The lesion comprises an irregular bone mass with large foramina connected to vessels. Micro CT imaging shows that the mass involves extensive cortical destruction with medullary involvement. Zonation with bone maturation, which is typical for fracture calluses, is not well developed. The thickening of cortical bone with a normally smooth surface is observed immediately proximal to the lesion, suggesting this part can be attributable to a Codman triangle. The gross and internal morphology of the pathological metatarsal suggests that the lesion can be diagnosed as an advanced osteosarcoma.

Although only two individuals are represented in the present material, a larger monodominant bonebed of a small-bodied oviraptorosaurs in the same formation provokes the idea that the present material might be derived from part of a small theropod herd. The previously identified osteosarcoma in a dinosaur was also from an assemblage containing multiple individuals. The advanced level of osteosarcoma in both cases indicates that the pathological deformation of bones heavily reduced their locomotor performance, yet the individuals survived a substantial amount of time with the lesion. These occurrences of osteosarcoma suggest that the gregarious behaviors of these animals were effective in reducing predation pressure.

**Funding Sources** This work was supported by Private University Research Branding Project (Japanese Ministry of Education, Culture, Sports, Science and Technology: MEXT).

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

## THE CROSS DATING OF A PALEOGENE TYOPTHERIA TO DETERMINE THE AGE AND RANGE OF THE CACHAPOAL

Itie, Preston D.

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South America for most of the Cenozoic Era has been isolated. Due to its isolation, this led to the mammals of this period being endemic. The Cenozoic has been divided into the South American Land Mammal Ages or SALMA. A recently established SALMA, the Tinguiriričan, may possibly have a bigger geological range. Deposits in the Cachapoal River Valley 74 km east of the village of Termas del Flaco have been hypothesized to be part of the Tinguiriričan SALMA. To answer this question, I describe a fossil from the Cachapoal River Valley to determine whether the Cachapoal River Valley is Tinguiriričan in age. Using my description, I compared the characters I identified with other specimens and used phylogenetics to determine the species. The results of my studies indicate that a fossil is a sister group with *Protypotherium australe* and *Miocochilius.* The geological ranges of these taxa make them younger than the Tinguiriričan and indicate that the Cachapoal River Valley is not of the Tinguiriričan age.

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Technical Session 21: Squamates (Saturday, October 21, 2023, 1:45 PM)

## GREATER ANTILLEAN *ANOLIS* SKULLS AS A REPLICATE MODEL SYSTEM FOR STUDYING ADAPTIVE RADIATION AND EVOLUTIONARY CONVERGENCE

Jacisin, John, Meza, Antonio, Xu, Tianyi, Boville, Alexandra, Kemp, Melissa

Department of Integrative Biology, University of Texas at Austin, Austin, Texas, United States

*Anolis* lizards are a model system for studying adaptive radiation, evolutionary convergence, and ecomorphology. Specifically, Greater Antillean Caribbean anoles have adaptively radiated into six distinct habitat specialist groups, or ecomorphs, with morphological features that are suited toward navigating specific environmental niches. While squamate skull morphology is known to be under selection by factors including environmental conditions, diet, predation, and competition, this has not been extensively investigated in *Anolis* lizards. The skull is interesting in the context of adaptive radiations, as there may be selective pressure to explore new morphospace afforded by novel niches, but constraint given the skull's role in vital life functions. We used landmark- and semilandmark-based 3D geometric morphometrics (GMM) on 366 skulls representing 61 species to explore how extant species of Greater Antillean *Anolis* partition morphospace, and to what extent morphological traits express phenotypic divergences consistent with a multi-peak adaptive landscape. We identified five axes of skull shape variation (~75% of total variation) representing statistically significant ($p < 0.05$) differences in morphology between ecomorphs and between islands. Larger islands with longer *Anolis* occupancy filled more morphospace and contained more ecomorphs. The combination of convergence in ecomorphs and constraints (e.g., island formation and historical biogeography) somewhat obscured detection of ecomorphological differences in the overall dataset. However, individual island subsets showed morphological differences in specific regions of the skull, such as in the mandible, as well as in overall skull shape, including skull depth and relative proportions of the preorbital versus postorbital skull. Ecomorphs using broad surfaces exhibited deep, broad skulls, while ecomorphs specializing on narrow substrates possessed shallow, slender skulls. Our results suggest that *Anolis* skulls have a common modular pattern with high integration and anisomerism. *Anolis* skull morphologies are complicated both by divergence across ecomorphs and islands, and by convergence within ecomorphs. Finally, the importance of island and ecomorphological patterns in skull shape suggests that GMM can help identify fossil *Anolis* ecomorph affinity and unveil the shifting phenotypic adaptive landscape of the *Anolis* radiation across the Greater Antilles during past periods of environmental change.

**Funding Sources** This research is funded by NSF EAR grant 2050228, to Dr. Melissa Kemp.

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Technical Session 21: Squamates (Saturday, October 21, 2023, 1:45 PM)

**THE PAST, PRESENT, AND FUTURE OF DRAGONS: USING ECOMETRICS TO STUDY THE RESPONSES OF AUSTRALIAN *VARANUS* COMMUNITIES TO CLIMATE CHANGE**

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Anthropogenic climate change is an increasingly important driver of community composition, particularly for poikilotherms, for which physiology is closely tied to environmental conditions. Modelling techniques predict the spatial responses of communities to climate change, but most models of climate change responses are trained on data from contemporary ecosystems and struggle to account for flexibility that may be evident in ecosystems at wider temporal scales. The fossil record provides additional data on the relationship between organisms and climate but has historically been limited to shallow-time records due to limited species durations of extant taxa. Taxon-free ecometric approaches are one way to overcome this limitation, allowing larger and older communities of ecologically similar extinct species to be studied as proxies for extant species.

We utilized ecometrics to study the response of varanid lizards, a clade of ecologically important poikilotherms, to climate change. We modelled the relationship between varanid community body size distributions and climate in Australia as a proxy for community responses to climate change. We modelled changes in varanid communities through the Pleistocene and compared fossil data to model outputs to calculate the flexibility of the group to respond to changing climatic conditions. We then made predictions about the responses of varanid communities to anthropogenic climate change, incorporating flexibility identified from the fossil record.

We find that models trained on modern communities generally underpredict varanid body size in the Pleistocene even when excluding extinct giants like *V. priscus*, suggesting that current and future climatic conditions can support larger species than predicted by models alone. However, we also find that predicted changes in varanid communities in response to even mild anthropogenic climate change scenarios far exceed the flexibility indicated by the

fossil record. Our models predict the loss of larger varanids such as *V. giganteus* from much of their range by as soon as 2100.
These results show that, even when accounting for the flexibility of species to adapt to changing climates, anthropogenic climate change is likely to cause major disruptions to poikilotherm communities. Combining the paleoclimatic record with data from the fossil record is vital in forming robust, accurate models of community responses to climate change.

**Funding Sources** This project was funded by the Natural Environment Research Council Cambridge Climate, Life, and Earth Doctoral Training Partnership.

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Virtual Posters

**A FOSSIL BOX TURTLE FROM NEAR THE MIOCENE-PLIOCENE BOUNDARY AND ITS POTENTIAL ROLE IN THE SEMI-AQUATIC TO TERRESTRIAL LIFESTYLE TRANSITION DURING THE EVOLUTION OF *TERRAPENE* (EMYDIDAE)**

Jasinski, Steven E.

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A new fossil box turtle (Emydidae: *Terrapene*) from near the Miocene-Pliocene boundary in eastern Tennessee, USA provides potentially important data on the presumed semi-aquatic to terrestrial transition in the evolution of these turtles. Extant *Terrapene* are nearly all fully terrestrial, except *T. coahuila*, which spends much of its time in the water and can be considered semi-aquatic (to aquatic). As other emydids are semi-aquatic, there was a transition from semi-aquatic to terrestrial either in the closest fossil ancestors of *Terrapene*, or early during its evolution. The new fossil box turtle comes from the latest Hemphillian-earliest Blancan North American Land Mammal Age but is not the earliest representative of the genus. Features of the shell show similarities with the semi-aquatic *T. coahuila*. Additionally, features preserved on some shells are interpreted as damage from bacteria, common when infections occur under the scutes of turtles living in aquatic habitats. Features of the forelimb, particularly dealing with the distal radius, suggest a wider forelimb than extant *Terrapene*, potentially being more useful for swimming than exclusively terrestrial locomotion. Phylogenetic analyses suggest the new fossil turtle lies outside crown *Terrapene*. As the new species is not the earliest member of *Terrapene*, it is possible one lineage of *Terrapene* maintained a more aquatic lifestyle. It is more likely, however, that this fossil *Terrapene* represents a return to this lifestyle, just as *T. coahuila* likely also represents a recent return to this more aquatic ancestral lifestyle.

**Funding Sources** Partial funding provided by National Science Foundation (NSF grant 0958985; PIs Steven C. Wallace and Blaine W. Schubert) for excavation of fossil material.

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**CHANGES IN THE PARIETAL FORAMEN TRACK MAJOR EVENTS IN AMNIOTE EVOLUTION**

Jenkins, Kelsey M., Gordon, Caleb M., Bhullar, Bhart-Anjan S.

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The parietal foramen is an opening in the skull for the parietal eye, a photosensitive outpocketing of the brain that was previously hypothesized to have a role in prompting the behavioral regulation of circadian rhythms and thermoregulation. However, it has also been suggested that latitude has an effect on the presence or absence of the parietal foramen. Among amniotes, the parietal foramen is lost in many tetrapods today, with the exception of many squamates and *Sphenodon*, but this feature was once widespread among tetrapods in the Paleozoic and the earliest phases of the Mesozoic. To explore if the function of this organ in extant amniotes is related to latitude, we sampled the lizard *Anolis sagrei* (n=57) from three isolated localities at different latitudes. We found no statistical differences in the size of the parietal foramen across latitudes, allowing us to entertain the notion that behavior as it relates to thermoregulation may play a greater role in the presence of this feature than latitude. Additionally, we surveyed the fossil record of pan-reptiles and pan-mammals from the Carboniferous through the Triassic to determine how the size of the parietal foramen has changed in these lineages over time. There is an increase in the size of the parietal foramen in several clades of early amniotes from the

early to middle Permian, which we hypothesize better aided in thermoregulation during climatic extremes found on Pangea related to continental climate. We found that in several lineages, the parietal foramen decreases in size or disappears completely at the Permo-Triassic boundary. This supports the idea that unique behavioral shifts towards fossoriality and endothermy, traits that may correlate with survivorship during the largest mass extinction in Earth's history, negate the need for a thermoregulatory organ such as the parietal eye.

**Funding Sources** National Science Foundation, Yale Department of Earth and Planetary Sciences, Yale Institute for Biospheric Sciences, Sigma Xi, Western Interior Paleontological Society

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Technical Session 9: Sauropsids (Thursday, October 19, 2023, 1:45 PM)

**POSTCRANIAL PLESIOMORPHIES AND HINDERING HOMOPLASY: THE IMPORTANCE OF TAXONOMIC AND POSTCRANIAL CHARACTER SAMPLING IN EARLY AMNIOTE PHYLOGENIES**

Jenkins, Xavier A.[1], Benson, Roger B.[2], Choiniere, Jonah[3], Ford, David[4], Peecook, Brandon R.[1]

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The origins and early evolution of Amniota have experienced a recent resurgence in study, with disparate conjectures for their ancestral bauplan implied by competing hypotheses for the placement of several key clades (Recumbirostra, Varanopidae, Parareptilia). Evidence from cranial morphology (e.g., patterns of fenestration or braincase ossification) is fundamental for these phylogenetic hypotheses. However, the impact of postcranial anatomical data in deciphering broader amniote relationships is still poorly understood. To evaluate postcranial evidence for amniote relationships, we reviewed the anatomy of early branching taxa and CT-scanned the poorly known postcrania of owenettid and millerettid 'parareptiles'. These scans reveal anatomy of the vertebrae, girdles, and limbs that are derived relative to early branching reptiles (e.g. Captorhinidae or Araeoscelidae). In particular, millerettids share numerous potential postcranial synapomorphies with middle Permian varanopids or neodiapsids to the exclusion of other amniotes. Relevant traits include: holocephalous ribs, laterally-projecting caudal ribs fused to the centra, a single coracoid, and an entepicondylar foramen positioned distal to the ectepicondylar groove. A review of early amniote postcranial anatomy reveals that characters previously interpreted to be synapomorphic of clades are more broadly distributed than previously realized, and at least some of this distribution is likely attributable to homoplasy, particularly within 'Parareptilia' and Varanopidae. Many published postcranial apomorphies of mesenosaurines are present in several clades of coeval neoreptiles but absent in supposed synapsid relatives: the loss of a pubic tubercle, the absence of a fourth trochanter, a broad, posteriorly oriented postacetabular process of the ilium.

When we incorporate these observations into an expanded phylogenetic dataset, much of this presumed homoplasy is reduced if Varanopidae is polyphyletic, with a synapsid placement of Varanodontinae and a neoreptile placement of Mesenosaurinae, as well as if 'Parareptilia' is a paraphyletic grade. These relationships are preliminarily supported in both postcranial and cranial partitions of our phylogenetic analyses. Our findings identify the critical importance of an adequate postcranial sampling in a phylogenetic dataset, and the incorporation of small-bodied parareptiles and neodiapsids is necessary to accurately reconstruct the plesiomorphic reptilian bauplan.

**Funding Sources** ISU Graduate School; Biology Graduate Student Association ISU

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Technical Session 3: Fishes & Amphibians (Wednesday, October 18, 2023, 8:00 AM)

**BONE REPAIR IN THE DEVONIAN LUNGFISH *DIPTERUS VALENCIENNESI* AFTER INJURY**

Johanson, Zerina[1], Leyhr, Jake[2], Challands, Tom[3], Violaris, Anaxagoras[1], Sanchez, Sophie[2], Dollman, Kathleen[4], Smith, Moya[5]

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[3]University of Edinburgh, Edinburgh, United Kingdom, [4]ESRF, Grenoble, France, [5]King's College London, London, United Kingdom

*Dipterus valenciennsi* (Dipnoi; Sarcopterygii) is a Middle Devonian lungfish from the Orcadian Basin, Scotland, with a skull comprising numerous dermal bones and an anterior rostrum with many sensory structures. The sensory system includes superficial rostral tubuli, opening via pores at the skull surface. A vascular supply runs between these, all underlain by an open network of cancellous bone, as revealed by synchrotron imaging (PPCSR-mCT). Although bone abnormalities are rarely preserved in fossil fishes, we describe a specimen of *Dipterus* showing signs of injury in the form of a small, rounded, protruding lesion near the anterior margin of the rostrum. Internally, the rostral tubuli are broken, as is the underlying cancellous bone; between these is a region of newly deposited bone, with some similarity to the rostral tubuli and cancellous bone but modified. Resorption occurs in the superficial cosmine layer of the lesion, and internally within the bone, showing classic markers for this process, as part of the repair process. The new bone, formed in the ventral region of the lesion, is the location of the first response to the breakage, stabilizing the damaged region, with rostral tubuli bringing nerves here along with blood vessels between the tubuli, both active in repair. This represents one of the oldest examples of dermal bone repair in sarcopterygian fishes. Lesion/callus formation is a common response in dermal bone repair, although co-option and modification of existing bone types such as the rostral tubuli in this repair, may be unique for lungfish.

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**COLLAGEN- AND CARBONATE-DERIVED CARBON ISOTOPES OF CANIDS AND FELIDS FROM C3 DOMINANT ECOSYSTEMS IN NORTH AMERICA: INVESTIGATING TISSUE SPECIFIC DIFFERENCES**

Johnson, Solathus[1], Feranec, Robert[2], Pardo, Justin R.[1], Southon, John[3], DeSantis, Larisa[1]

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The motto, “you are what you eat” is well documented in the stable isotope ecology literature. Despite decades of research on stable isotopes, relationships between disparate tissues within the same individual are both less studied and far less understood. Recent work on fossils from Rancho La Brea and modern specimens from primarily $C_4$ dominant ecosystems indicate that the spacing between collagen and carbonate is not constant across ecosystems. For example, preliminary results reveal that this offset value (i.e., the offset between enamel carbonate and bone collagen) is positively correlated with the enamel carbonate values of carnivorans. Further, the consumption of $C_3$ or $C_4$ consuming prey may be a driving factor of these differences. Here, we aim to clarify relationships between different tissues in canids and felids living in $C_3$ environments. Specifically, we sampled enamel carbonate, dentin carbonate, dentin collagen, bone carbonate, and bone collagen of canids (consisting of extant *Canis lupus* and *Canis latrans*) and felids (consisting of extant *Lynx rufus* and *Lynx canadensis*) from $C_3$ dominate environments (i.e., environments where prey are not consuming any $C_4$ resources) in northern North America (i.e., New York and Alaska). These data are rarely gathered on the same specimens due to the destructive nature of sampling. Results indicate that the offset between carbonate and collagen values varies depending on the tissues being compared (e.g., dentin carbonate vs. dentin collagen as compared to offsets between enamel carbonate vs. bone collagen). Further, these offset values are not static in carnivorans as previously assumed. These data are an important complement to data derived from $C_4$ ecosystems and further studies examining taxa across these thresholds could provide information to our understanding of collagen- and carbonate-derived carbon isotopes. Lastly, this work is highly relevant and necessary to understanding carnivoran diets through time.

**Funding Sources** National Science Foundation and Vanderbilt University.

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Technical Session 19: Theropods - II (Saturday, October 21, 2023, 1:45 PM)

**FINITE ELEMENT ANALYSIS OF FEEDING FUNCTION IN THE SKULL OF *SPINOSAURUS***

Johnson-Ransom, Evan D.[1], Snively, Eric[2], Sereno, Paul C.[1], Ross, Callum[1]

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The spinosaurid skull, which has an elongate snout bearing conical teeth, grossly resembles the condition in longirostrine crocodylians and has been interpreted as primarily piscivorous in feeding function. Biomechanical first principles suggest that *Spinosaurus* should exhibit higher cranial stresses when loaded during jaw closing than deeper-snouted theropods such as *Tyrannosaurus*. We estimated overall adductor forces in *Spinosaurus* by multiplying areal cross sections within the subtemporal fenestra by an assumed tension (31.5 $N/cm^2$), with individual muscle forces proportioned as estimated previously in *T. rex*. These muscle forces were applied to finite element analyses (FEA) to evaluate cranial and mandibular stress in an updated skull model of *Spinosaurus*, with bone properties as in *Alligator*. To simulate a range of symmetrical bite forces, we used fully-fixed and rotation-permitted constraints at the jaw joint with bite force applied at several positions along the tooth rows. The subtemporal fenestra had a relatively small cross-sectional area that generated an estimated total adductor muscle force of 21,385 N, which is approximately one-half that estimated for *Carcharodontosaurus* (39,157 N) and only one-third that estimated for *T. rex* (59,373 N). *Spinosaurus* exhibited higher von Mises stress in the cranium and mandible than *T. rex*. In symmetrical bite simulations, stress was concentrated in the nasals and pterygoids and was notably lower on the rostrum, even with an anterior bite. Mandibular stress was more dramatic than in the cranium of *Spinosaurus*, with high stress in the angular and ramus of the dentary, particularly under fully-fixed constraints.

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Education & Outreach Poster Session (Saturday, October 21, 2023, 4:30 - 6:30 PM)

## ASSESSING MIDDLE SCHOOL STUDENT ACCURACY IN IDENTIFYING VERTEBRATE MICROFOSSILS FROM THE UPPER CRETACEOUS HELL CREEK FORMATION

Jones, Elizabeth D.[1], Kanipe, John[1], Avrahami, Haviv M.[1], Cullen, Thomas[2], Zanno, Lindsay E.[1]

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There are numerous opportunities for the public to formally and informally learn about paleontology but few that directly involve the public in the process of conducting research and producing knowledge. Cretaceous Creatures, a new public science project, seeks to fill this gap through its three-fold mission to inspire, educate, and collaborate with students across North Carolina, nationally, and internationally. This four-year project (launched in 2022) engages 8th grade teachers and students in discovering and identifying microfossils from 66–67 million-year-old sediment from the Hell Creek Formation, Montana. Through direct access to microfossil material and a custom online interactive identification module, students are building an original paleobiodiversity database. However, the utility of this database, and future prospects of the project, depend on accurate identifications of microvertebrate fossils.

Here, we evaluate the efficacy of the Fossil Discovery Module—an online, multiple-choice, and classification-based decision tree with 48 possible microfossil identifications—as a tool for helping students correctly identify specimens. We consider the impact of multiple variables on the accuracy and precision of identifications, including preservational quality, taxon, and element. Between October 2022 and May 2023, ~2,500 students working in teams of 3–4 identified 1,192 "microfossils". Of these, 35% (421) were non-fossil objects. To date, we have re-identified 747 of the 771 of the fossils discovered by the students. We found that 57.6% of student identifications were correct in both the taxon and element; 8.4% correctly identified the element but indicated the wrong taxon; 0.5% correctly identified the taxon but identified the wrong element; and 33.5% of the identifications were incorrect for both categories. To explain this, we analyzed the accuracy of student identifications by comparing the taxon, element, and preservation quality (i.e., perfect, partial, or poor) of each correctly and incorrectly identified fossil. In doing so, we find a statistically significant correlation ($P<0.00001$) between preservational quality and students' ability to correctly identify the taxon and element. These results suggest that the overall efficacy of the Fossil Discovery Module can be improved by including detailed lessons on how taphonomy affects fossil preservation (and therefore identification) and differentiating between non-fossil and fossil objects.

**Funding Sources** This project is made possible by an Anchor Grant from the Bank of America Charitable Foundation to Dr. Lindsay Zanno.

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Symposium Session: Theropod Flight Origins (Thursday, October 19, 2023, 1:45 PM)

### EVOLUTION OF EOCENE BATS AND THE ORIGINS OF MODERN GROUPS

Jones, Matthew F.[1], Baez, Justin R.[1], Upham, Nathan S.[1], Beard, K. Christopher[2], Simmons, Nancy B.[3]

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Bats appear in the fossil record during the early Eocene (~56–55 Ma) on multiple continents. More than seventy Eocene bat species have been named to date, including stem bats, probable members of crown families, and others of uncertain affinity. Most phylogenetic analyses of Eocene bat relationships have focused on the handful of taxa known from nearly complete skeletal material, whereas the taxonomic relationships of more incomplete fossils are based largely on phenetic similarities. We evaluated the evolutionary relationships of over sixty species of Eocene bats—including many taxa known only from fragmentary craniodental remains—in an explicit phylogenetic context. Our analysis is based on nearly 700 morphological characters scored in 82 taxa, including 20 extant species representing nearly all living bat families. We found that phylogenetic relationships of Eocene bats are more complex than previously thought. Four major clades of stem bats were recovered in our analyses, although relationships among stem taxa differed from previous analyses. Numerous families (e.g., Archaeonycteridae, Mixopterygidae, Palaeochiropterygidae) and genera (e.g., *Archaeonycteris*, *Icaronycteris*, *Carcinipteryx*) were found to be nonmonophyletic as previously recognized, requiring adjustments to chiropteran taxonomy. Many purported crown bats were recovered instead among stem Chiroptera; however, the oldest crown bats were recovered during the early Eocene. This research has the potential to shed light on the origins of Chiroptera and has implications for understanding patterns of dispersal for early bat clades and the timing of development of powered flight.

**Funding Sources** This research was supported by a Society of Systematic Biologists Mini-ARTS Grant, KU Biodiversity Institute Panorama Grant, and the David B. Jones Foundation.

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

### A NEW ASSEMBLAGE OF PROBOSCIDEAN FOSSILS FROM CENTRAL INDIA AND ASSOCIATED STRATIGRAPHIC AND TAPHONOMIC OBSERVATIONS

Joshi, Aarya M.[1], Tanksale, Mihir[1], Poojari, Rajesh[1], Chopra, Sumedha[2], Srinivas, Aakash[3], Patnaik, Rajeev[4], Sukumaran, Prabhin[5], Kaur, Anubhav Preet[1], Deshpande, Atharva[1], Padhan, Tosabnta[1], Singh, Vivek[1], Chauhan, Parth[1]

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Proboscidean fossils from India have been discovered and studied since the 19th century. While the Narmada basin of central India is highly fossiliferous, discoveries of abundant skeletal elements of proboscideans in minimally-disturbed contexts are rare, with the majority of the collections being isolated fragments recovered from surface contexts. Here, we present a new fossil assemblage from the fossil hominin site of Hathnora, which was found to contain multiple skeletal elements such as ribs, humerus, vertebrae, etc. of a proboscidean, possibly all belonging to a single individual. Fossils were discovered to be buried under sediment sharing proximity with the bank of the Narmada River. The discovery of these in-situ fossils consisting of multiple post-cranial elements of a Proboscidean has given us an excellent opportunity to document, study, and analyze Proboscidean fossils from India. The lithostratigraphy at Hathnora shows that the context of the fossils is part of the Baneta formation which has been dated to 35.66 ± 2.54. The fossil assemblage is fragmented, with 209 fossil specimens documented until now. No human cultural remains were found to

be buried along with the fossil assemblage. Analysis of the degree of completeness, refits, and morphology of the breaks and their distribution suggests that the majority of the bone breakage has occurred post-burial due to desiccation and sediment movement or compaction. The bones show a weathering stage of 3 indicating pre-burial exposure of the bones for 4 to 15 years. The fossils show signs of negligible transportation, leading us to believe that the Proboscidean fossils were recovered from a primary context, which is a rare occurrence in central India. These results provide us with an opportunity to further assess the relation of the fossil assemblage with its stratigraphic context. Furthermore, the primary context of the fossils, the presence of lithic artefacts in the surrounding area, and the presence of the fossil hominin at the site in proximity open up an opportunity to compare the geological contexts and the relationship between these faunal remains and hominin presence at the site.

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Technical Session 4: Dinosaur Soft Tissues (Wednesday, October 18, 2023, 1:45 PM)

**INTEGUMENTARY IMPRESSIONS ON HADROSAURID SPECIMENS FROM THE UPPER CRETACEOUS (UPPER CAMPANIAN) DINOSAUR PARK FORMATION, ALBERTA, CANADA REVEAL GREAT DIVERSITY IN INTEGUMENT PATTERNS AND MANUAL SOFT-TISSUE MORPHOLOGY**

Joubarne, Tristan[1], Therrien, François[2], Zelenitsky, Darla K.[1]

[1]Geoscience, University of Calgary, Calgary, Alberta, Canada, [2]Royal Tyrrell Museum of Palaeontology, Drumheller, Alberta, Canada

Dinosaur skin impressions provide information about scale morphology, scale patterns, and soft-tissue ornamentation that are otherwise unknown from skeletal elements. They are predominantly known for hadrosaurids, in which a wide variety of scale types and arrangements have been recognized; however, integument for some regions of the body, such as the anterior torso and the manus, are poorly represented. Three indeterminate hadrosaurid specimens with extensive skin impressions were studied to document scale type and pattern on regions of the body for which soft-tissue morphology and patterns are poorly known. The specimens include a juvenile individual preserving articulated forelimbs and feet and the articulated (isolated) manus of two adult individuals, all recovered from the Upper Cretaceous (upper Campanian) Dinosaur Park Formation of Alberta, Canada. Skin impressions on the anterior torso of the juvenile hadrosaurid reveal a scale pattern of alternating small polygonal (2-3 mm in diameter) and pebbly (1-2 mm in diameter) basement scales arranged in vertical bands at least 10 cm wide, indicating the individual displayed vertical stripes in life. Alternating colored stripes producing disruptive coloration to avoid detection by predators have been documented in extant animals that live in open habitats. Additionally, integument preserved on the manus of two specimens show that digits II-III-IV were of subequal length and united in a common fleshy structure that differs from the condition previously described in exceptionally preserved *Edmontosaurus annectens* “mummies”, in which digit II is apparently shorter and partly isolated from the fleshy structure uniting digits III-IV. As such, there may be more variation in soft-tissue morphology of the manus among hadrosaurids than previously realized. The three specimens examined improve understanding of the diversity of scale patterns and soft-tissue morphology within Hadrosauridae.

**Funding Sources** FRQNT (Québec) (TJ), Roger Soderstrom Scholarship (TJ), Alberta Graduate Excellence Scholarship (TJ), NSERC Discovery grant (DKZ).

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Technical Session 17: Afrotheria & Mammal Macroevolution (Saturday, October 21, 2023, 8:00 AM)

**A POSSIBLE NEW MAMMUTID FROM THE HAGERMAN FOSSIL BEDS**

Jukar, Advait M.

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The diversity of fossil mammutids (true mastodons) is grossly underappreciated across the world. In North America, mammutids are found from the middle Miocene to the Pleistocene. The number of genera, and number of dispersals from Eurasia, and evolutionary radiation is largely unknown. Herein, I report on a remarkably complete proboscidean cranium from the Glenns Ferry Formation in the Hagerman Fossil Beds of Idaho. The specimen, USNM V 15688, has previously been labelled as an indeterminate gomphothere, *Gomphotherium* sp., and

*Cuvieronius* sp. However, the dentition suggests affinities to the Mammutidae, such as antero-posteriorly compressed transverse crests, broad transverse valleys, zygodont crests on the posttrite lophs, and pretrite crescentoids that descend into the transverse valleys. The M2s are more worn than the M3s and show the development of diamond-shaped occlusal wear on the lophs, which is another characteristic of mammutids. The dentition is more bunodont than that of typical *Mammut*, suggesting a different genus. The tusks are not well preserved, though appear to be downturned; however, without a preserved external enamel band, the attribution to the genus *Zygolophodon* cannot be confidently made. The evidence does indicate that it is a mammutid, and potentially a new species, which has implications for mammutid diversification dynamics in North America fitting with recent studies that highlight the complexity of mammutid systematics in the region.

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Technical Session 18: Synapsids (Saturday, October 21, 2023, 8:00 AM)

**CRANIAL ANATOMY AND PALEOBIOLOGY OF AN ABUNDANT TRAVERSODONTID CYNODONT FROM THE LATE TRIASSIC OF EASTERN NORTH AMERICA**

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Historically, Triassic vertebrates from eastern North America were very poorly sampled compared to their well-known counterparts from the American southwest. This is changing, however, based on work on a variety of rich Triassic assemblages in the Newark Supergroup. As a notable example, recent excavations in the Deep River Basin of central North Carolina have produced plentiful remains of a wide variety of Carnian-Norian tetrapods at multiple localities. While including many typical tetrapod groups of the time (e.g., metoposaurs, phytosaurs, aetosaurs, paracrocodylomorphs), some of these localities differ sharply from most known southwestern faunas in being numerically dominated by non-mammalian synapsids. Here, we present new cynodont material from the Deep River Basin, known primarily from a single quarry in which cynodonts represent the most abundant taxon. Over 100 specimens have been found so far, including complete skulls, jaws, and articulated postcrania. This cynodont fauna is so far monospecific, with all recovered individuals referable to the traversodontid taxon *Boreogomphodon*, previously known from fragmentary specimens in potentially coeval deposits in the Richmond Basin of Virginia. Referral to *Boreogomphodon* is based on postcanine morphology, details of bone sculpturing on the snout, and presence of an elongate mental foramen. The new specimens provide unprecedented detail on the anatomy and ontogeny of this taxon, rendering it one of the most completely known Triassic cynodonts. Micro-computed tomography of two of the best-preserved specimens demonstrates that *Boreogomphodon* has a simple, tubular brain endocast as in most early cynodonts. However, this taxon has a very unusual otic labyrinth with a greatly expanded vestibule. Based on comparisons with extant taxa and other non-mammalian synapsids, this suggests a dedicated fossorial lifestyle for *Boreogomphodon*. Curled burrow casts are abundant at the locality yielding these fossils; although no cynodont specimens have yet been found *in situ* within the casts, based on size and morphology, a cynodont maker is probable. Phylogenetic analysis incorporating the new material strongly supports a position for *Boreogomphodon* within an endemic clade of Northern Hemisphere traversodontids, which appears to have been a more important component of at least some Laurasian faunas than previously thought.

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**AN ANALYSIS OF *ARCHAEOPTERYX*'S DENTAL MORPHOLOGY VIA GEOMETRIC MORPHOMETRICS**

Kantelis, Theron M., Carney, Ryan

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*Archaeopteryx* roots our understanding of stem Avialae, but non-concrete and contradictory dietary data on this taxon prevents us from establishing a basal diet for the larger clade. This study aims to provide foundational data for a preliminary reconstruction of *Archaeopteryx*'s diet by identifying dietary trends within tooth morphology among maniraptorans and early birds. Geometric morphometrics were employed to study the dentition of *Archaeopteryx*, with care given to ensure that the morphologies of premaxillary, maxillary, and dentary teeth were not homogenized. Sensitivity analysis shows minimal inter-observer variation. Although dietary interpretations are somewhat limited by a dearth of concrete data for early birds, broad functional interpretations can be made for some. Our results reveal that the premaxillary teeth of *Archaeopteryx* exhibit a relatively unique morphology amongst avialans, and a relatively homogeneous morphology within the genus. In contrast, the maxillary and dentary teeth do not display distinct morphologies from each other and span a range of functional morphologies. The premaxillary teeth of *Archaeopteryx* cluster relatively tightly in morphospace alongside the premaxillary teeth of presumed invertivores, granivores, and durophages. The maxillary and dentary teeth inhabit a range of morphospaces that extends amongst the entire range of functional morphologies studied here. While a robust dietary reconstruction cannot be formed on this data alone, we interpret these results to suggest that *Archaeopteryx* may have premaxillary teeth well-adapted for processing hard foodstuffs, such as hard-bodied insects, nuts, or seeds, and that its maxillary and dentary teeth remained relatively unspecialized, allowing for a generalistic/opportunistic diet. Additionally, the wide range of variation in maxillary and dentary tooth morphology could alternatively represent adaptive diversity within *Archaeopteryx*, with specimens inhabiting different dietary niches. Furthermore, we find no correlation with ontogeny or stratigraphy. Future biomechanical studies of the functional capabilities of these premaxillary teeth will be needed to confirm their durophagous capabilities, and additional specimens of *Archaeopteryx* may be required to substantiate any hypotheses regarding diversity within the group. Our study underscores the importance of considering tooth morphology in dietary reconstruction and proposes a potential basal dietary adaptation for Avialae.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**A MAXENT PREDICTIVE MODEL FOR PALEONTOLOGICAL SITES IN THE SIWALIK HILLS; A CASE STUDY FROM THE PINJORE FORMATION OF THE SIWALIK HILLS NORTH OF CHANDIGARH, NORTHERN INDIA**

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[1]Humanities and Social Sciences, Indian Institute of Science Education and Research Mohali, Chandigarh, Chandigarh, India, [2]University of Notre Dame, Notre Dame, Indiana, United States

The Pinjore Formation of the Upper Siwalik Hills north of Chandigarh, northern India, is one of the most continuous and extensive Early-Middle Pleistocene deposit. It is well-known for its rich deposits of fossilized vertebrate faunal remains, chronologically ranging from 2.58-0.63 Ma. However, most have been reported as surface finds of an unconfirmed geological association. In order to better understand the Pinjore biostratigraphy, new surveys were initiated in the region in November 2020. A MaxEnt predictive model was generated to guide the surveys in the region. The main objectives of this model were: 1) to identify new fossil scatters closer to the context. 2) to evaluate the applicability and accuracy of predictive models generated using MaxEnt for identifying fossil localities in the Siwalik Hills region. 3) to generate a replicable predictive model through this case study. Primary data consists of environmental variables that include slope, aspect and NDVI (vegetation index). The input data used 14 previously known fossil localities from the study area. The model's accuracy was evaluated through field surveys concentrated around regions predicted with a high-moderate possibility for the presence of fossil sites. As a result, six new fossil localities, with multiple scatters, have been identified in the Pinjore Formation of the Siwalik Hills north of Chandigarh. Further efforts are now being directed towards improving the model enhancing its spatial resolution.
**Funding Sources** The Lithic Studies Society; The Royal Anthropological Institute; The Paleontological Society; The Leakey Foundation

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Technical Session 10: Euarchontoglires & Xenarthra (Friday, October 20, 2023, 8:00 AM)

**ENDOCASTS OF *HOMUNCULUS PATAGONICUS* (PRIMATES, PLATYRRHINI) DEMONSTRATE THAT ANTHROPOID-LIKE NEOCORTICAL PROPORTIONS WERE ESTABLISHED BEFORE THE EVOLUTION OF SUBSTANTIAL BRAIN SIZE ENLARGEMENT IN PLATYRRHINES**

Kay, Richard F.[1], Allen, Kari[2], Bargo, M S.[3], Kirk, Edward C.[4], Morse, Paul E.[5], Organ, Chris[6], Vizcaino, Sergio F.[3]

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Although extant anthropoids generally have larger brains relative to body size than other primates, fossil endocasts have demonstrated that increased encephalization evolved independently in platyrrhines and catarrhines. Furthermore, extant platyrrhines exhibit substantial interspecific variation in brain size and endocranial volume relative to body mass. Stem platyrrhines *Chilecebus, Dolichocebus, Homunculus,* and *Tremacebus* from 17 to 21-million-year-old sediments of Patagonia all have small endocranial volumes (ECVs) for their body masses compared with extant platyrrhines; instead, their relative ECVs are within the extant strepsirrhine range. However, little attention has been given to changes in the proportions of different brain regions as revealed on the surfaces of fossil endocasts. In this study, we compare the surface area of the exposed neocortex from 230 primate virtual endocasts, sampling all extant families and >95% of all extant primate genera, as well as the stem anthropoid *Simonsius grangeri*, the stem catarrhine *Aegyptopithecus zeuxis*, *Tremacebus harringtoni*, and several specimens of *Homunculus patagonicus*. Using anatomical surface features to delimit homologous brain regions, we measured the proportions of the frontal, temporal, and parieto-occipital surface areas of the neocortex. We find that extant platyrrhines share similar neocortical proportions irrespective of relative endocranial volume. *H. patagonicus* and *T. harringtoni* have platyrrhine-like neocortical surface proportions even though they have much smaller ECVs relative to body size than any extant platyrrhine. Compared with extant strepsirrhines, extant and extinct platyrrhines have relatively enlarged temporal plus parieto-occipital neocortical regions and proportionally smaller frontal neocortices. Similar neocortical proportions are also observed more broadly in crown haplorhines (including tarsiers, catarrhines, and stem anthropoids). We interpret this difference in neocortical proportions as being related to the evolution of enhanced visual processing in crown haplorhines, possibly related to the acquisition of increased visual acuity. We hypothesize that a grade shift from strepsirrhine to haplorhine neocortical proportions, characterized by an increase in sizes of neocortical areas devoted to visual processing in the posterior neocortex, was established in haplorhines prior to the parallel evolution of increased encephalization in multiple anthropoid lineages.

**Funding Sources** NSF BNS 1349741 to RFK, NSF 1232534 to KA and RFK, PICT 2017-1081 to MSB and UNLP 11/N867 to SFV

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Technical Session 12: Methods & Paleohistology (Friday, October 20, 2023, 8:00 AM)

## DENTAL HISTOLOGY AND CT DATA OF EARLY CRETACEOUS *DILONG PARADOXUS* SHED LIGHT ON TYRANNOSAUROID TOOTH REPLACEMENT EVOLUTION

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Tyrannosauridae is an intriguing paradox clade in terms of tooth replacement. While simultaneous development of multiple tooth generations within one alveolus (dental battery) is uncommon in amniotes and frequently linked with herbivory and/or high tooth replacement rates (TRRs), the carnivorous tyrannosaurids are known to have some members developing second-generation replacement teeth (SGRTs) and with an extremely low TRR. It is currently unknown when and how this unique feature evolved because little data is available on dental cycling in non-tyrannosaurid tyrannosauroids.

Here we present high-resolution CT scan data and 3D reconstruct the dentition including all tooth generations of two specimens (IVPP V14242 and V14243) of *Dilong paradoxus*, an Early Cretaceous tyrannosauroid that is closely related to tyrannosaurids. SGRTs are present in both specimens of *D. paradoxus* and they increase in number with ontogeny and are often associated with the largest functional teeth, suggesting a functional adaptation. Thus, the presence of SGRTs has a wider phylogenetic distribution in Tyrannosauroidea than previously known and is even featuring small-sized taxa. Through the coronal thin section of an *ex situ* tooth of IVPP V14242, we estimate that it has a mean von Ebner line increment width (VEIW) of 14 µm, comparable to other theropods including tyrannosaurids. Via VEIW and dentin layer thickness from CT scan data, the estimated TRRs of both specimens of *D. paradoxus* are about 60 days, much higher than those in Tyrannosauridae.

With SGRTs and a relatively high TRR, *D. paradoxus* is more similar to other dinosaurs with dental batteries than to Tyrannosauridae. The unique tooth replacement pattern (i.e., having SGRTs but low TRRs) in Tyrannosauridae thus has a late origin in tyrannosauroid evolution, and is possibly linked with both the peculiar bone-cracking feeding strategy and accommodating the gigantism due to the upper limit of dentine apposition rates and activity of odontoblasts in this group. Finally, *D. paradoxus* is similar to tyrannosaurids and the non-tyrannosauroid theropods with SGRTs in having relatively thick tooth crowns and robust roots, which may slow the resorption and shedding of functional teeth and thus benefit the predation.

**Funding Sources** This study was supported by the National Natural Science Foundation of China (42288201, 41972025).

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Technical Session 11: Archosaurs (Friday, October 20, 2023, 8:00 AM)

**QUANTIFYING THE SHAPE OF THE TEETH OF A RARE HERBIVOROUS CLADE OF ARCHOSAURS IN THE TRIASSIC USING 3D GEOMETRIC MORPHOMETRICS AND DISCRETE ANALYSIS**

Keeble, Emily[1], Fitch, Adam[1], Foffa, Davide[1], Paes Neto, Voltaire[2], Parker, William G.[3], Reyes, William[4], Nesbitt, Sterling J.[1]

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Teeth are often used to infer ecology and diversity of extinct vertebrates. Plesiomorphic archosaur teeth indicate carnivory, though on various occasions, including rarely in the Late Triassic, we see a leap to herbivory. Aetosaurs are the most speciose of the Late Triassic herbivorous archosaurs, making them excellent to study shape and variation in teeth across genera that made this transition. Here, we investigate differences in aetosaur dentition using qualitative and quantitative methods and aim to create protocols that could be used to make repeatable isolated tooth identifications. 3D models of 40 aetosaur teeth (*Aetosauroides, Coahomasuchus kahleorum, Longosuchus, Neoaetosauroides, Calyptosuchus, Stagonolepis robertsoni, Stenomyti*) and 51 outgroup taxa teeth (*Euparkeria, Ornithosuchus, Parringtonia, Revueltosaurus, Riojasuchus*) were made from surface or µCT scans. We quantified tooth types (premaxillary, maxillary, dentary) in individuals, where present, to test the full spectrum of tooth shape and identify trends in the regions of the mouth. 3D geometric morphometrics (3D GM) analyzed shape variation using 5 fixed landmarks and 1000 semilandmarks and was complemented by non-metric multidimensional scaling (NMDS) to visualize differences in teeth scored for discrete characters and provide further separation between taxa and tooth type. 3D GM results place most teeth into one cluster, though *C. kahleorum* plots away due to its unusual carnivorous dentition. *S. robertsoni* and *Revueltosaurus,* with relatively short, rounded teeth, also diverge from the main cluster, though less than *C. kahleorum.* Generally, teeth from the same individual plot together, even if from different regions of the mouth. *Aetosauroides* is the exception, taking up a wide area. These results are echoed in the NMDS plot, where: (i) most aetosaur taxa cluster together with the same divergent genera among the outliers; (ii) teeth of the same individual cluster together, except for (iii) *Aetosauroides* that occupies the widest area amongst our sampled taxa. As each tooth type from each genera plots together, and the majority of aetosaurs plot together, inserting isolated or suspected aetosaur teeth into this analysis could help us determine their affinity to Aetosauria. With proof of concept, we can expand these methods to examine other taxa to provide quantified and repeatable microsite identifications, thus allowing us to trace diversity, ecology, and faunal change through time.

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Preparators' Session (Thursday, October 19, 2023, 8:00 AM)

**DESIGN AND SAFE JOURNEY TO A 21ST-CENTURY FOSSIL LAB**

Keillor, Tyler, Sereno, Paul C.

University of Chicago, Chicago, Illinois, United States

The Walker Museum at the University of Chicago predated the Field Museum of Natural History but closed its doors in 1965. Paleontological research on campus arose anew into a thriving program, but now without a collection or preparation facility. Thus, some 25 years ago with the advent of large scale field operations, a Fossil Lab was created in temporary space in the Enrico Fermi Institute, a WWII era building slated for demolition in 2021. With no available campus space, the Fossil Lab turned to a warehouse of 6,000 sq. ft. in a neighborhood adjacent to campus. How best to design and move a fossil lab into a neighborhood?

Working with architects, we identified workspaces to facilitate both research and community engagement. That process began with the building's facade, where we added a framed mural space for rotating display of artwork and a new backlit logo. The entry corridor is lined with transparent glass looking into the prep lab. A large learning room combines collections and research areas with mobile tables and carts for class engagement activities. A kitchenette and large screen facilitate teaching at all levels, meetings, or movie events. Engineers accommodated needs for large-specimen transit between all rooms (garage door street access, level concrete floors, double doors eight feet wide, mobile gantry crane) and compressed air, dust collection and power for ten benchtop work areas plus heavy duty mobile tables.

Move-in required custom packing for small fragile specimens to multi-ton blocks. We injected quick setting platinum silicone to seal cracks in a large fossil block of soft sandstone containing the remains of a precious dinosaur mummy. Fiberglass-reinforced plaster support shells lined with polyethylene foam protected massive sauropod bones. Smaller fossils were protected in custom boxes made with corrugated plastic sheets and various thicknesses of polyethylene foam supports. Small specimens in collections cabinets were padded in polyethylene-lined trays, and movers transported entire packed cabinets into the new lab. All arrived safely in ample time to arrange an open house for neighborhood schools and the general public. While not a public institution on the scale of a museum, a Fossil Lab in a neighborhood can have remarkable positive local impact.

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Romer Prize Session (Thursday, October 19, 2023, 8:00 AM)

**CLIMATE AND BIODIVERSITY LOSS SHAPE MICROMAMMAL COMMUNITY ECOLOGY OVER THE LAST 22,000 YEARS AT HALL'S CAVE, TEXAS**

Keller, Jonathan S.

Biology, University of New Mexico, Albuquerque, New Mexico, United States

North American micromammal communities endured the terminal Pleistocene megafaunal extinction and post-glacial warming with relatively minor turnover. To characterize how these communities persisted in situ, we examined fossils of ten micromammal taxa (*Geomys*, *Thomomys*, *Neotoma*, *Sigmodon*, *Microtus*, *Chaetodipus*, *Onychomys*, *Reithrodontomys*, and two *Peromyscus* morphotypes) found throughout the 22,000 year record at Hall's Cave, Texas. We evaluated community ecology over time via microCT-derived 3D dental ecomorphological diet proxies from lower jaws (n>600), $\delta^{13}C/\delta^{15}N$ isotopic niche (n>2000), and body size measures for each taxon (n>6000) spanning 13 time intervals. Analyses were nested such that all jaws analyzed for 3D dental ecomorphology were also sampled for $\delta^{13}C/\delta^{15}N$ stable isotopes, and body size was reconstructed for all specimens sampled for isotopes using dental allometric regressions. We characterized isotopic niche width using Bayesian standard ellipse areas (SEA), targeting 15 individuals/species/time bin. We quantified mean pairwise niche overlap between all taxa within each time bin as a proxy for potential resource competition. For most taxa, isotopic niche widths contracted in the Holocene consistent with decreased habitat heterogeneity. Potential resource competition increased from <45% in the Pleistocene to >55% in the Holocene. More defaunated, homogenous Holocene micromammal communities may thus experience greater interspecific competition relative to megafauna-generated, mosaic Pleistocene habitats. Different micromammal taxa responded to climate change and biodiversity loss with unique shifts in body size and isotopic niche. For several taxa, dental ecomorphology shifted together with stable isotopes, suggesting rapid adaptation. MicroCT scans facilitated species-level identifications, revealing finer-scale patterns of body size and diet adaptation as well as coexistence of multiple congeneric species for some taxa. Climate variables generally best explained body size shifts over time within taxa, but biodiversity loss associated with the terminal Pleistocene megafaunal extinction briefly overwhelmed the climate body size signal and permanently shifted micromammal community dynamics at Hall's Cave. Our results emphasize the cascading effects of megafaunal extinction and climate change at the microfaunal level and inform long-term ecological consequences of modern anthropogenic extinctions in a warming world.

**Funding Sources** Funding sources included the UNM Gaudin and Grove scholarships, American Society of Mammalogists, Geological Society of America, and NSF (DEB grant #1555525).

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Technical Session 6: Marine Reptiles (Wednesday, October 18, 2023, 1:45 PM)

### DIVERGENT EVOLUTIONARY TRAJECTORIES OF THALATTOSAUROID AND ASKEPTOSAUROID THALATTOSAURS (DIAPSIDA: THALATTOSAURIA)

Kelley, Neil[1], Bastiaans, Dylan[2], Druckenmiller, Patrick S.[3], Klein, Nicole[2], Liu, Jun[4], Metz, Eric T.[5], Sander, Martin[6], Scheyer, Torsten[2]

[1]Earth and Environmental Sciences, Vanderbilt University, Nashville, Tennessee, United States, [2]University of Zurich, Zurich, Switzerland, [3]University of Alaska Fairbanks, Fairbanks, Alaska, United States, [4]Hefei University, Hefei, China, [5]Museum of the Rockies, Bozeman, Montana, United States, [6]University of Bonn, Bonn, Germany

Thalattosauria is a group of marine reptiles that were widely distributed across the Northern Hemisphere during the Triassic Period. They can be divided into two distinct clades, Askeptosauroidea and Thalattosauroidea, based on differences in cranial, appendicular, and axial anatomy. However, relationships within these groups remain poorly resolved. We present the results of the most extensive phylogenetic analysis of Thalattosauria conducted to date including 26 operational taxonomic units scored for 78 characters. As with previous analyses we find strong support for the monophyly of Thalattosauria, and their inclusion within Diapsida, although their affinities among diapsids remain unclear. The respective monophyly of Askeptosauroidea and Thalattosauroidea is also generally well supported. Internal relationships among Askeptosauroidea are better resolved than Thalattosauroidea, likely due to a higher proportion of articulated skeletons in the former. This taphonomic trend may reflect the more robust skeleton of askeptosauroids and their more restricted occurrence within basins along the northern margin of the Tethys Ocean. Conversely, the poorer phylogenetic resolution within Thalattosauroidea may reflect reduced ossification and their occurrence in more pelagic settings, resulting in a greater proportion of disarticulated and fragmentary remains. Many thalattosauroids are also highly autapomorphic, contributing to poor intraclade resolution. Recent histological study of askeptosauroids and thalattosauroids underscores the disparity between these groups, with askeptosauroids possessing much more compact and well-organized bone microanatomy. In contrast, the highly cancellous bone of thalattosauroids more closely resembles pelagic ichthyosaurs and plesiosaurs. These histological differences accord with the divergent biogeographical modes of the two clades, where askeptosauroids were apparently restricted to the Tethys for their entire existence, whereas thalattosauroids dispersed across the Tethys and northern Panthalassa early and perhaps repeatedly across their evolutionary history. Despite these different lifestyles and evolutionary histories, both askeptosauroids and thalattosauroids disappeared in the Late Triassic, victims of the major reorganization in marine ecosystems across the Triassic-Jurassic mass extinction.

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

### COMMENTS ON PTEROSAUR BONE BEDS

Kellner, Alexander W.

Geology and Paleontology, Museu Nacional/UFRJ, Rio de Janeiro, Rio de Janeiro, Brazil

Although pterosaurs have been recovered on all continents, their record is rather patchy and most occurrences consist of fragmentary material. So far only a few pterosaur bone beds have been reported in the literature. The most important ones are the Lagarcito formation (Albian, Argentina), the deposits of Hami (Lower Cretaceous, China), and the "pterosaur graveyard" site at Cruzeiro do Oeste (Turonian-Campanian, Brazil). The Lagarcito layers consist of sandstones and mudstones deposited in a lacustrine environment and represent a shallow lake in a semiarid region, with the fossil occurrences limited to a small area (~50m$^2$). The sole pterosaur reported is *Pterodaustro guinazui* which is the most common fossil vertebrate. Specimens vary from well-articulated individuals to isolated bones, with eggs (only two), juveniles, and ontogenetically more mature individuals rare.

The Hami deposits consist mainly of sandstones and mudstones that represent rivers and lakes.

*Hamipterus tianshanensis* is by far the predominant fossil in the region. There are several horizons, consisting of isolated elements that are widespread over an immense area (several kilometers). Juveniles and ontogenetically more mature individuals are rare. Numerous eggs, some containing embryonic remains, have been found. The horizons with pterosaur remains and eggs have been interpreted as tempestites resulted from large storms that might have been at least partially responsible for mortality events. *H. tianshanensis* also shows sexual dimorphism expressed by the shape of the rostrum and cranial crest.

The deposits of Cruzeiro do Oeste consist of fine-grained sandstones with the fossiliferous layers confined to a small area (~30m$^2$). Although pterosaur specimens predominate, contrary to the previous bonebeds, two species were reported (along with extensive theropod material). By far the most predominant is the small (~1.5m wingspan) tapejarine *Caiuajara dobruskii*, represented for all by young individuals. The second species, *Keresdrakon vilsoni*, is larger (~3m wingspan) and is known by few specimens, all sub-adults (no juveniles). No eggs were found so far. Most specimens are disarticulated, but closely associated. The distinct features observed in these pterosaur bonebeds potentially reflect variations in behavior and palaeoecological differences but also suggest that gregarious behavior might have been widespread among pterosaurs, at least within the derived Pterodactyloidea.
**Funding Sources** Funding: FAPERJ #E-26/201.095/2022 and CNPQ #313461/2018-0, #406779/2021-0, #406902/2022-4.

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Paleontological Management Poster Session (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

## RECOMPOE - AN INITIATIVE TO OBTAIN ORIGINAL ITEMS FOR THE EXHIBITIONS OF THE MUSEU NACIONAL/UFRJ

Kellner, Alexander W.

Geology and Paleontology, Museu Nacional/UFRJ, Rio de Janeiro, Rio de Janeiro, Brazil

The Museu Nacional/UFRJ is not only the largest museum of natural history and anthropology in Brazil, but also the first scientific institution in the country. On September 2, 2018, this institution suffered a tragic fire that destroyed about 85% of the collections, estimated at around 20 million items. Among the lost specimens were thousands of paleontological items, from plant material and invertebrates to reptiles, mammals, and fishes. The rescue activity of objects inside the palace was sponsored by the Brazilian Ministry of Education, the Federal University of Rio de Janeiro (UFRJ, to which the museum is incorporated) and the German government (which donated one million euros) and supported by UNESCO. This action resulted in the recovery of some hundreds of paleontological specimens, including holotypes of various fossil reptiles (e.g., *Santanaraptor placidus*, *Anhanguera blittersdorffi*, and *Tapejara wellnhoferi*) and the iconic material from Luzia - among the oldest osteological remains of human occupation in South America dating back around 12,000 years. Nonetheless, the loss was tremendous.

Following the recent visit of President Lula and several ministers to the palace, the Brazilian government has indicated that rebuilding the Museu Nacional is a priority and there are plans to reopen much of the exhibition space in early 2026. However, the main problem will be the displays, as almost all the items of the previous exhibitions have been destroyed or have been badly damaged, requiring special restorations. For this reason, the RECOMPOE campaign (www.recompoe.mn.ufrj.br) was developed, aimed at recomposing the institution's exhibition collection.

Most of the main themes that will be developed concern the evolution and diversification of life over deep time. The origin of vertebrates, the development and diversification of animals in the seas, the first fish, the conquest of land, the first reptiles, the evolution of dinosaurs and crocodylomorphs, and the emergence and disappearance of the megafauna are some of the topics that are will be addressed. Additionally, specific themes such as hearing and flight development are also planned to be incorporated.

To be successful, there is a great need for original specimens, which cannot be accomplished without intense international cooperation. The reconstruction of the Museu Nacional/UFRJ is an opportunity to show the world what collaborations between institutions around the globe can achieve.

**Funding Sources** Funding: FAPERJ #E-26/201.095/2022 and CNPQ #313461/2018-0, #406779/2021-0, #406902/2022-4.

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**MIDDLE MIOCENE UNGULATES FROM THE SIWALIK HILLS OF PAKISTAN: SYSTEMATIC AND BIOGEOGRAPHIC IMPLICATIONS**

Khan, Abdul Majid[1], Rafeh, Amtur[1], Ahmad, Rana Manzoor[2]

[1]Institute of Zoology, University of the Punjab, Lahore, Pakistan, [2]Department of Zoology, Government College University, Lahore, Lahore, Pakistan

Mammals are an economically, ecologically and culturally significant animal group. The living representatives of this group are facing many environmental challenges in the current changing climatic conditions. The understanding of their prehistoric representatives and their ecological interactions will be important for the conservation of mammalian diversity. Thus, a detailed taxonomic investigation of fossil mammalian material from the Middle Miocene Siwaliks of Northern Pakistan was undertaken. Fifty-two fossil remains included in this study were collected from several localities in the Middle Miocene Siwalik subgroup of Pakistan. Fossil families recovered include the Bovidae, Giraffidae, Suidae, Tragulidae and Rhinocerotidae. The material is housed at the Institute of Zoology, University of the Punjab, Lahore, Pakistan. Fossils include isolated maxillary and mandibular teeth, most of which are premolars and molars, fragments of maxillae and a dentary with an incomplete dental series. The systematic study of the specimens was carried out by comparisons of morphometric features with the previously reported dental characters of the Siwalik mammals. The paleoecological implications for the Middle Miocene Siwalik mammalian communities was studied by using carbon and oxygen stable isotopes and enamel hypoplasia analysis. The carbon and oxygen isotope values indicate that the Middle Miocene Siwalik mammals of Pakistan were living in an ecosystem that are exclusively C3 vegetational systems where the Early Middle Miocene atmosphere was less humid as compared to the Late Middle Miocene which was dominated by tropical forest. The enamel hypoplasia results show that the representative species of the five Siwalik mammalian families faced physiological and/or ecological stress during the Middle Miocene epoch, which was low to moderate in nature. This stress may have been caused by a strong wave of immigrant taxa including artiodactyls and rodents during the Middle Miocene. Another possible factor was the regression in sea level which exposed the routes from one continent to another and caused faunal exchanges until the start of the Middle Miocene. This study adds to the detailed literature on the mammalian fauna and paleobiogeography of the Middle Miocene Siwaliks of Pakistan.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**SPECIES OCCURRENCES OF LATE MIOCENE HORSES (EQUIDAE) FROM FLORIDA: SAMPLING, ECOLOGY, OR BOTH?**

Killingsworth, Stephanie[1], MacFadden, Bruce J.[2]

[1]Geology & Florida Museum of Natural History, University of Florida, Gainesville, Florida, United States, [2]Florida Museum of Natural History, University of Florida, Gainesville, Florida, United States

A persistent challenge in paleontology involves the issue of sampling bias, because portions of the past have been erased from the fossil record. Gaps in the record occur for a number of reasons such as scavenging or decay, diagenesis, or break down and recycling of crust through tectonic processes. What fossils we have collected versus those we have yet to uncover, as well as those we will never know, leaves many questions unanswered.

At a more localized level, when the age of a fossil locality is constrained the absence of expected taxa based on this age may raise further questions as to whether temporal or ecological reasons are at play. Scientists must address presence and absence of taxa as an outcome of sampling bias or to missing taxa simply not existing in a specific locality for ecological reasons.

This project compares fossil horse specimens collected from two Florida Miocene (late Hemphillian) localities: the Montbrook Fossil Site (MFS) and the Palmetto Fauna (Bone Valley Region). Both localities have used the North American Land Mammal Ages (NALMAs), or biochronological dates of vertebrate fossils to give an age of late Hemphillian (Hh4: 6.0-5.0 Ma). During the late Hemphillian, four horse species were widespread across the North American continent. These were *Nannippus aztecus* (3-toed horse), *Neohipparion eurystyle* (3-toed horse), *Astrohippus stocki* (1-toed horse), and *Dinohippus mexicanus* (1-toed horse). In addition to the above four ubiquitous horse species, Florida had two additional endemic horse species- *Pseudhipparian simpsoni* (3-toed) and *Cormohipparion emsliei* (3-toed).

More than 300 fossilized teeth have been cataloged and identified to the species level from the Bone Valley Palmetto Fauna; accounting for all six Hemphillian horse species. Notably, however, only four of the six horse species from just over 100 identified teeth and postcranial fossils are found within the Montbrook collections.

A rarefaction simulation was completed using the Vegan package in R to answer the question of whether the absence of both 1-toed horses at MFS, *Astrohippus stocki* and *Dinohippus mexicanus*, is due to a true sampling bias or if paleoecology of the area better explains their absence. The results indicate that a simple, single explanation cannot account for only four late Hemphillian species at Montbrook. Our study indicates that this number of horse species likely was a combination of both sampling bias and ecological differences.

**Funding Sources** The Montbrook fossil horses studied were collected and curated with support from National Science Foundation (NSF) project 1203222 and the Felburn Foundation.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

## MILK EFFECT ON TOOTH ENAMEL, BREATH, AND FASTING OF SMALL MAMMALS FROM FEEDING-CONTROLLED EXPERIMENTS FOR CARBON STABLE ISOTOPES

Kimura, Yuri[1], Yamada, Keita[2], Casanovas-Vilar, Isaac[3], Cerling, Thure E.[4], Seki, Azusa[5]

[1]National Museum of Nature and Science, Tsukuba, Japan, [2]Tokyo Institute of Technology, Kanagawa, Japan, [3]Institut Català de Paleontologia Miquel Crusafont, Barcelona, Spain, [4]University of Utah, Salt Lake City, Utah, United States, [5]Hamri Co. LTD., Koga, Japan

Isotopic analyses have been well established for the past decades to infer food sources, predator-prey interactions, dietary niche, and seasonal migrations for mammals in modern and fossil communities. Stable carbon isotopic composition of tooth enamel reflects the weighted contribution of $C_3$ and $C_4$ plants to consumed diet, generally linking to the overlying vegetation in the habitat of the animals. For large herbivorous mammals, an empirically-measured value of +14 per mil has been used as the isotopic enrichment factor between bioapatite and diet. However, such experimental studies have been hardly conducted for small mammals and result in limited applicability of small mammals for isotopic paleoecological inferences.

Here, we examined feeding-controlled experiments using four species of rodents: *Mus musculus* (mice), *Rattus rattus* (rats), *Mesocricetus auratus* (golden hamsters), and *Meriones unguiculatus* (Mongolian gerbils) to derive the enrichment factor of carbon and model intra-dentition isotopic variations. The rodents were raised with commercial rat chow (oat, corn, etc.) and corn-free formulated chow with water of known isotope values. We monitored carbon isotopes (δC) of breath for pairs of a mother and its offspring during lactation and continued to monitor that of offspring until >Day 40. The cubs were separated from their mother at Day 20 (=weaning) and fed with the same diet as the mother until euthanized at >Day 60. $CO_2$-laser ablation was used for isotope analysis on molar enamel. The whole experiments were conducted between 2018 and 2022 with approval in accordance with the Guidelines for the Care and Use of Laboratory Animals (AAALAC International). The mother-offspring paired δC values of breath show that δC values of cubs were more negative than those of mothers by a few per mil and that the milk effect is greater in the desert-adapted gerbil. Fasting pairs show that cubs heavily rely on mother milk in the early stage of lactation. In mice, for which breath data were obtained more densely, δC of cub breath captured a logarithmic change from milk-dominated to diet with increased intake of adult diet. Combining all species, carbon isotope values of molar enamel also show a logarithmic pattern along the timing of tooth eruption. These data suggest a consistent value of ~11 per mil for the enrichment factor regardless the phylogenetic distances among the examined taxa.

**Funding Sources** JSPS KAKENHI 21K15176, PID2020-117289GBI00(MCIN/AEI/10.13039/501100011033/), GenCat/CERCA Programme, AGAUR (2021 SGR 00620)

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Technical Session 7: Birds (Thursday, October 19, 2023, 8:00 AM)

## TIMING OF DIVERSIFICATION, DISPERSAL, AND BIOGEOGRAPHY OF PARROTS IN THE GENUS *AMAZONA* (PSITTACIFORMES: PSITTACIDAE) THROUGHOUT THE CARIBBEAN, VISUALIZED IN GIS

Kingwill, Christopher

Fort Hays State University, Pleasant Prairie, Wisconsin, United States

Avian fossil records from across the Caribbean (Greater and Lesser Antilles) demonstrate higher avian diversity prior to extinction events due to climate change at the end of the Pleistocene and human impact across the Caribbean throughout the Holocene. Amazon parrots (*Amazona*) are a diverse genus of New World parrots found throughout Central and South America, as well as the Caribbean. Their phylogeny and evolutionary history, specifically for Caribbean species, has been debated in terms of source areas in Central and South America and the timing of and number of colonization events to different islands that preceded diversification into island-endemic forms. Taking a geospatial approach using GIS to study dispersal and biogeography of Caribbean amazon parrots, this study uses modified bathymetric data to model sea level fluctuations during the Late Pliocene (3.6 Ma – 2.58 Ma), the Pleistocene (2.58 Ma – 12 ka), and the Last Glacial Maximum (LGM) (~12 ka) to model potential paths of dispersal to islands of the Caribbean from inferred source regions on the mainland. Network Analyst and Euclidean distance raster analysis in ArcGIS Pro 3.0 are utilized to create an optimal series of network pathways and inferred flight regions of the Caribbean at each time interval, based on an estimated maximum flying distance for amazon parrots. Previous phylogenetic information (for mainland and insular Caribbean amazon species) and *Amazona* fossil records are utilized as supplementary information to contemporary *Amazona* distributions in the Caribbean in this study. Network route, Euclidean distance, and fossil distribution mapping results added geographic context to the dispersion patterns of Greater Antillean amazons and offered a hypothesis for the diversification of Lesser Antillean amazons in spite of their paraphyletic status and poorly known evolutionary history.

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Technical Session 5: Ungulates (Wednesday, October 18, 2023, 1:45 PM)

## A NEW SPECIES OF ANTILOPINI FROM THE PLEISTOCENE OF THE CENTRAL HIGHLANDS, KENYA

Kirera, Francis M.[1], Omuombo, Christine[2], Malit, Nasser R.[3], Waweru, Veronica[4], Kinyanjui, Rahab[5], Chege, Lorna[6], Kinyua, Richard[7], Ndiritu, Francis[8], munge, Stephen[5], Grossman, Aryeh[9]

[1]Biomedical Sciences, Mercer University School of Medicine, Macon, Georgia, United States, [2]Department of Geosciences and the Environment, Technical University of Kenya, Nairobi, Kenya, [3]Anthropology, SUNY Potsdam, Potsdam, New York, United States, [4]Council on African Studies at the MacMillan Center for International and Area Studies, Yale University, New Haven, Connecticut, United States, [5]Department of Earth Sciences, National Museums of Kenya, Nairobi, Nairobi, Kenya, [6]Unaffliated, Nairobi, Kenya, [7]Freelance Unaffiliated, Gatarakwa, Kenya, [8]Geosciences, Georgia State University, Atlanta, Georgia, United States, [9]Anatomy, College of Graduate Studies, Midwestern University, Glendale, Arizona, United States

The newly discovered high-altitude Plio-Pleistocene hominin-bearing sites near Ngobit in the Central Highlands of Kenya (CHK) have yielded a diverse vertebrate fauna including crocodilians, turtles, fish, and mammals. The mammals include proboscideans, perissodactyls, carnivorans, cetartiodactyls, primates, and rodents. Most mammalian fossils belong to the family Bovidae. Among these is a new species of springbok Antidorcas nov. sp. The new species is represented by horncores and dentognathic remains. We compared the new materials with other bovids using comparative anatomy and phylogenetic systematics. Unique features that warrant designation as a new species include robust posteriorly bent stocky horncores, extremely thick central enamel, and molars with dumbbell-shaped central cavities. The phylogenetic analysis places the Antidorcas linguae nov. sp. as a sister clade with the extinct *A. bondi*, although the general morphology of the horncores resembles those of *A. recki* and the extant *A. marsupialis*. The discovery of a new species of bovid among other mammals markedly expands our knowledge of the biogeography, diversity, and range expansion of the Antidorcas genus and other mid-Pleistocene fauna in the East African upland ecosystems. It also highlights the significance of complex high-altitude topographic ecosystems in the evolution of fauna.

**Funding Sources** The Wen-Gren Foundation, PAST South Africa, Mercer University, Seed Grant

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

## A NEW, DIVERSE FOSSIL ELEPHANT ASSEMBLAGE FROM MID-PLIOCENE ESHOA, KENYA, INCLUDING THE FIRST SUB-SAHARAN MAMMOTH SKULL

Kirinya Muthuri, Martin[1], Leakey, Louise N.[1], Leakey, Meave G.[1], Gichunge Ibui, Timothy[1], Mbete Mbatha, Pauline[2], Sanders, William J.[3]

[1]Paleontology, Turkana Basin Institute, Nairobi, Kenya, [2]Paleontology, National Museums of Kenya, Nairobi, Kenya, [3]Museum of Paleontology, University of Michigan, Ann Arbor, Michigan, United States

Elephant fossils from Eshoa, located near the southwest side of Lake Turkana, Kenya, derive from sediments dating to ~3.5 Ma. Morphometric study of dental and skull remains from the site indicate the presence of multiple extinct species of crown elephant genera. Recently collected adult mandibles with m3s belong in *Elephas recki brumpti*. Their corpora are laterally swollen, broad and relatively short. The m3s have 11 plates, prominent posterior accessory conules, and transverse profiles broadest one-third of plate height above the crown base. They are moderately hypsodont. A number of other molars from the site resemble those of *Loxodonta adaurora*, with mesodont crowns, thick enamel, low lamellar frequencies, prominent anterior and posterior accessory conules, and rounded transverse profiles that are widest at the base. The m3s have 10 plates. Unexpectedly, a new adult cranium from Eshoa is consistent with assignment to *Mammuthus*. Its petite size (length, 840 mm) suggests that it is a "diminutive" or represents a dwarfed species. This cranium is tall, anteroposteriorly compressed, and has condyles raised well above the occlusal plane, at the same level as the orbits, and strongly downturned tusk alveoli. Its nasal aperture is broad, the nuchal crest is rounded with no midline sulcus, the temporal lines are narrowly spaced, the tusk alveoli are parallel, and there is no occipitoparietal bossing or inflation of the occipital planum. Its M3s have 10 plates. Posterior accessory conules are limited to the first two plates. The M3 crowns are low, but relative to their very narrow widths yield hypsodont molar indices. It does not resemble crania of other, contemporary African elephant taxa. A dentary associated with the cranium has an equally low and narrow m3, with 11 plates spaced at high lamellar frequency. These specimens comprise the first formally-reported mammoth skull from sub-Saharan Africa. The composition of the assemblage reveals a taxonomically robust relay interval replacing Mio-Pliocene archaic elephants prior to Plio-Pleistocene dominance of the *Elephas recki* group in eastern Africa and implies conditions very different from any modern ecosystem.

**Funding Sources** National Geographic Society and the Turkana Basin Institute Research Fund.

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Technical Session 10: Euarchontoglires & Xenarthra (Friday, October 20, 2023, 8:00 AM)

## NEW *OURAYIA* AND *MYTONIUS* (PRIMATES, OMOMYOIDEA) FROM THE TORNILLO BASIN OF TEXAS

Kirk, Edward C.[1], Dunn, Rachel H.[2], Rodwell, Ben[1], Townsend, K.E. B.[3]

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All omomyoid primates from the early Eocene of North America were relatively small-bodied and have estimated body masses less than 500 grams. By the middle Eocene, multiple lineages of North American omomyoids independently evolved body masses greater than 500 grams. However, most of the larger omomyoid taxa from the Uintan and Duchesnean NALMAs are known from very small sample sizes. This sampling bias has contributed to a lack of consensus regarding number of distinct omomyoid taxa from the middle Eocene, which has complicated attempts to understand the paleobiogeography of North American Eocene primates more generally. Here we describe new Uintan specimens of the large omomyines *Ourayia* and *Mytonius* from the Tornillo Basin of Trans-Pecos Texas. These new samples provide additional evidence that *Ourayia* and *Mytonius* are both valid genera distinct from *Macrotarsius*. Furthermore, when combined with expanded hypodigms of *Ourayia uintensis* and *Mytonius hopsoni* from the Uinta Basin of Utah, the Tornillo Basin sample favors the recognition of different species of *Ourayia* and *Mytonius* in Texas and Utah. These data suggest that *Ourayia* and

*Mytonius* are time-successive taxa with a wide distribution in intermontane basins of the Laramide region. More broadly, these new fossil samples help to elucidate the shifting patterns of regional endemism in North American primate faunas during the middle Eocene. In the early Uintan, primate faunas in the central Rocky Mountains and Trans-Pecos Texas were already quite distinct from those occurring in Southern California. By the late Uintan, primate faunas in all three regions demonstrated greater provincialism, with Trans-Pecos Texas and Southern California both exhibiting a large number of endemic primate taxa and sharing only a single primate genus (*Macrotarsius*) in common. This increase in primate endemism across the Uintan may be tied to changes in paleohabitats associated with long-term trends toward decreasing temperatures from the Early Eocene Climatic Optimum to the Eocene/Oligocene transition.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**NEW POLACANTHINE ANKYLOSAURS FROM THE BASAL CRETACEOUS (BERRIASIAN), LOWER YELLOW CAT MEMBER (YCM) OF THE CEDAR MOUNTAIN FORMATION (CMF), NORTHERN PARADOX BASIN, GRAND COUNTY, UTAH**

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The YCM unconformably overlies the Upper Jurassic Morrison Fm. It is the thickest member of the CMF in the Paradox Basin due to local salt tectonic-induced subsidence. A regional calcrete divides the YCM into lower and upper units. The lower YCM is characterized by stacked gravelly paleosols, whereas the upper YCM is finer grained, and includes lacustrine units east of Arches NP and paleosols with carbonate nodules west of Arches NP. The upper YCM fauna includes multiple dromaeosaur taxa including *Utahraptor*, the basal ornithomimid *Nedcolbertia*, brachiosaur (*Cedarosaurus*) and turiosaur (*Moabosaurus*) sauropods, multiple styracosternid iguanodontians, and the polacanthine ankylosaur *Gastonia burgei*. The upper YCM is Valanginian based on palynology, microfossils, chemostratigraphy documenting the Weisert anoxic event, and U/Pb ages of paleosol zircons. The lower YCM is Berriasian and preserves dromaeosaurs, multiple therizinosaurs including *Falcarius*, a large allosauroid, the turiosaur sauropod *Mierasaurus*, multiple styracosternid iguanodontians, and at least two polacanthine species, which we introduce herein.

The Doelling's Bowl Bonebed is in the lower half of the lower YCM. A minimum of two juvenile and one adult polacanthine are present including most skeletal elements. Two juvenile basicrania possess basiperygoid processes that are intermediate in length between the Jurassic *Mymoorapelta* and *Gastonia*, in which the articular surface with pterygoids is angled laterally as opposed to anteriorly. The lateral margins of the ilia are subparallel to the synsacrum as in *Mymoorapelta* and *Polacanthus*, opposed to the lateral flaring in *Gastonia*. The caudal plates are reclined as in *Mymoorapelta* and most dorsal osteoderms are unique in possessing a subcentral apex with corresponding ventral depression. The YCM is much thinner 30 miles (48 km) to the west at Suarez Site. There, a second new species of polacanthine was discovered at the top of lower YCM that is twice the size of the other ~ 5m long polacanthine genera noted above. It is distinguished by solid, plate-like, crested dorsal osteoderms, proportionally lower, rounded caudal plates, and the most massive first cervical ring of any ankylosaur. The major elements of its sacral shield are unique in being surrounded by a ring of distinct depressions. These new taxa add further evidence for intercontinental biogeographic connections between North America and Europe during the earliest Cretaceous.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**A NEW LACUSTRINE MARGIN VERTEBRATE ASSEMBLAGE FROM THE EARLY JURASSIC WATERFALL FORMATION OF VIRGINIA, U.S.A.**

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The Early Jurassic (Hettangian: 201 Ma) Waterfall Formation (WF) is the highest sedimentary unit of the Culpepper Basin (Newark Supergroup), and its limited outcrops represent the only definitively Early Jurassic strata in the state of Virginia. Here we present a new fossil assemblage from the (WF) at Bull Run Mountains Natural Area Preserve, Prince Williams County, VA, USA. Fossil-bearing strata at the new site comprise a thick (~10 m) interval of steeply-dipping (~40°), gray, heterogenous lacustrine microlaminated to laminated mudstones and sandstone to pebbly turbidites deposited during a high stand of climatic precessionally-paced lacustrine cycle, part of a very thick (>1000 m) cyclical sequence deposited within 1 km of the western margin of the Culpeper rift lake.

Plant macrofossils, preserved best in laminated mudstones, include conifer cones, shoots, and branches, Bennettitales (*Otozamites*) leaves, Equisetales stems, and indeterminate wood. Sporomorphs are dominated by the conifer pollen form *Classopollis* (78%) as well as much less common bisaccates (~2%), but abundant fern spores (~17%) including *Dictyophillidites* and *Todisporites* are also present, indicating a humid environment. Invertebrates, preserved best three-dimensionally and with original shell material found in muddy sandstones, include rare gastropods, abundant clam shrimp (*Bulbilimnadia* spinocaudatans), and ostracods (*Darwinula*). Actinopterygians, preserved best as flattened articulated skeletons found in microlaminated mudstones, include *Redfieldius*, *Ptycholepis*, and at least 5 morphotypes of *Semionotus*. Mawsoniid coelocanths are present and preserved as both two-dimensional and three-dimensional articulated skeletons, the former in microlaminated mudstones, and the latter in concretions. Coprolites, plausibly from coelacanths, are abundant. Theropod or crocodylomorph archosaurs are represented by labiolingually compressed, recurved, serrated teeth, possibly representing the first dinosaur body fossils from Virginia; these teeth are so far found exclusively in pebbly turbidites.

The WF is the southernmost Jurassic unit exposed in eastern North America, and the similarity of its fossil assemblage to coeval Newark Supergroup assemblages from over 600 km north in New Jersey, Connecticut, and Massachusetts shows the presence of similar vertebrate communities across 6° of paleolatitude of eastern North America in the Hettangian.

**Funding Sources** Virginia Museum of Natural History 2022 Pete Henika Memorial Fund; Heath Robinson-Roy J. Holden Scholarship Fund; David R. Wones Research Scholarship

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Technical Session 2: Early Mammals & Carnivora (Wednesday, October 18, 2023, 8:00 AM)

### DENTAL MICROWEAR TEXTURE ANALYSIS OF PLEISTOCENE CARNIVORES ON THE WEST COAST OF SOUTH AFRICA

Koehler, Kirsten M.[1], Faith, J. Tyler[2], Braun, David R.[3], Schwartz, Andrew F.[4], O'Brien, Kaedan[2], Sokolowski, Kathryn[2], Davies, Ben[2], Stynder, Deano[5], DeSantis, Larisa[1]

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The exceptionally diverse ecosystems of southern Africa's Cape Floristic Region (CFR) have been shaped by a long history of climate change and anthropogenic impacts. It is presently unclear when hominins began to rival bottom-up processes as a driver of ecological change in the CFR, though researchers working elsewhere in Africa have proposed that increasing hominin carnivory through the Pleistocene may have driven extinctions and ecological changes within the carnivore guild. With this in mind, we aim to provide a long-term perspective of ecological change through an examination of carnivore diets from fossil assemblages spanning much of the last ~1 million years: Elandsfontein (EFTM), Hoedjiespunt 1 (HDP1), Sea Harvest (SH), and Swartklip 1 (ZW1). We also establish a modern baseline for *Lupulella mesomelas* specimens, examining their dental microwear in South Africa, today. *Acinonyx jubatus* (n=1), *Vulpes chama* (n=5), *Panthera pardus* (n=3), *Panthera leo* (n=2), *Parahyaena brunnea* (n=11), *Lycaon pictus* (n=2), and *Lupulella mesomelas* (n=12) were examined from fossil localities using dental microwear texture analysis (DMTA) and compared to current benchmarks for extant canids and felids. This helped assess the dietary habits of these species, which persist to the present. Extant *L. mesomelas* (n=12) were compared to Pleistocene specimens (n=12), and extant *P. brunnea* (n=9) were compared to fossil specimens of *P. brunnea* (n=11). While it is necessary to be cautious about comparing DMTA attributes between carnivorans with low sample sizes, all DMTA attribute values fall within the range of modern specimens. Further, both *P. brunnea* and *C. mesomelas* currently consume harder foods (as demonstrated with significantly higher complexity values, p=0.048, p=0.046, respectively) than their Pleistocene predecessors. It is possible that modern brown hyenas and black-backed jackals may be utilizing carcasses to a greater extent than in the Pleistocene. Increased bone processing could be caused by easier access to carcasses, resulting from a decrease in kleptoparasitism, or the need to utilize carcasses due to a drop in prey numbers or increased competition with an expanded predator guild. Further research is required to distinguish between these possibilities.

**Funding Sources** National Science Foundation, University of Utah, George Washington University, University of Cape Town, and Vanderbilt University.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**FOSSILGAITSIM: A SIMULATION FRAMEWORK FOR GAIT OF EXTINCT QUADRUPED ANIMALS**

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Ancient animal locomotion has recently been investigated using biomechanical modelling and simulation studies, employing techniques developed mostly for human motion. We aim to investigate if these techniques can be used to study not only the gait of extinct animals, but also their morphometry. In biomechanical modelling and simulation studies, gait simulations are created by solving optimal control problems. The optimal control problem is solved to find an optimal gait cycle for a dynamics model that represents the animal. The objective of the optimization is to minimize energy expenditure, similar to the optimization used for movement planning by the central nervous system. The dynamics model and its parameters are derived from body fossils, but some of the resulting model parameter estimates are inaccurate, e.g., those related to mass and inertia. Therefore, we aim to use simulations to investigate these morphometric parameters, by finding the dynamics model and parameters for which the optimal control simulation best fits the trackways.

Here, we introduce a MATLAB framework that can be used to create optical control simulations of extinct animals' gait. The framework can be used to design different dynamics models that represent an extinct animal and investigate how well their respective simulations match trackways that are related to the animal. Different skeletal models can be created by varying the model parameters and the degrees of freedom, e.g., by adding or removing segments in the tail and the head, and by using different ranges of motion for the degrees of freedom. We present the framework and show some exemplary simulations that were created using this framework.

So far, we have used the framework to create a simulation of a quadruped animal with 3 degrees of freedom in each leg, and a trunk segment. The optimal control problem was solved by minimizing the squared torque, while constraining the gait cycle to be periodic. We solved for a walking gait at 0.5 m/s, using a standing simulation as initial guess. The resulting simulation displayed gait behavior typical for quadruped walking. Next, we aim to show the gait variations that can be obtained by varying the model's morphology. In the future, we aim to use this framework to investigate footprint patterns such as *Ameghinichnus patagonicus*, produced by an early mammaliaform of some sort, in Middle Jurassic outcrops in Patagonia, Argentina.

**Funding Sources** This research was funded by BAYLAT-CONICET Anschubfinanzierung awarded to ADK & VK and a Georg Forster Research Fellowship for Experienced Researchers awarded to VK

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Technical Session 6: Marine Reptiles (Wednesday, October 18, 2023, 1:45 PM)

**A NEW DERIVED MOSASAURINE (SQUAMATA: MOSASAURIDAE) FROM SOUTHWESTERN JAPAN REVEALS UNEXPECTED POSTCRANIAL DIVERSITY AMONG FLIPPER-BEARING MOSASAURS**

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Reported herein is an exceptionally well preserved mosasaurine mosasaur (Squamata: Mosasauridae) skeleton from Wakayama Prefecture, southwestern Japan. Represented by nearly 80% of skeletal elements including the skull, a string of more than 40 vertebrae, both front flippers, and the left hind flipper, the specimen derives from near the Campanian/Maastrichtian boundary (ca. 72 Ma) of the Hasegawa Muddy Sandstone Member of the Toyajo Formation. We assign the specimen WMNH-Ge-1140240002 to a new genus and a species to be based on the following suite of major characteristics: jaw bones gracile; premaxilla–maxilla suture terminating above or just posterior to fourth maxillary tooth; frontal median dorsal ridge robust; frontal alae broadly rounded; frontal descending processes extending parallel to each other; jugal process of postorbitofrontal extending laterally and constituting the dorsal half of posterior orbital margin; atlas articulation surface on occipital condyle extending anteroventrally; spacing between tooth crown bases less than basal length of adjacent crowns; anterior and posterior carinae on marginal teeth pinched out in cross-section; cervical centra compressed dorsoventrally; zygapophyses, zygosphenes, and zygantra present along dorsal vertebrae; neural spines typically twice or more as tall as centra; neural spine orientation changing from procumbent to recumbent along posterior dorsal vertebrae; front and hind flippers longer than mandible; hind flipper longer than front flipper; humerus dimension greatest between ectepicondyle and entepicondyle; entepicondyle medially expanded bearing facet distinct from ulnar articular facet; radius with articulation facet for lateral centrale; antebrachial foramen longer anteroposteriorly than proximodistally; phalanges hourglass shaped, highly waisted at mid-length; and hyperphalangy up to nine. The two sets of large, wing-shaped flippers were likely selected for fast maneuvering, such as seen in the humpback whale among extant cetaceans. The presence of a dorsal fin is indicated by the sweeping arrangement of the neural spines along the dorsal vertebrae, posterior to the presumed center of gravity of the mosasaur. Finally, the iliac process extends dorsolaterally, where its distal end would have been separated from the nearest vertebra by the distance approximately equal to or greater than the length of the pubis, indicating a distinct lack of the sacral region in this, and other, hydropelvic mosasaurs.

**Funding Sources** Town of Aridagawa, Wakayama Prefecture, Japan; Wakayama Prefecture, Japan; Ministry of Health, Labour and Welfare, Goverment of Japan.

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Colbert Poster Prize Session

## EVOLUTION OF THE TETRAPOD ATLAS-AXIS COMPLEX

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The separation of the skull from the shoulder girdle contributed, at least in part, to the success of the limbed vertebrates (herein “tetrapods”). This key evolutionary event gave rise to innovations in the anterior-most portion of the axial column that resulted in diverse morphologies at the skull–neck boundary among tetrapods. Early on, a soft tissue connection via the notochord dominated this critical anatomical junction; however, with the subsequent evolution of a boney vertebral column, a distinctive anatomical structure linking the skull to the rest of the vertebral column – the atlas-axis complex – appeared in the stem members of every clade of extant tetrapods. Despite its critical importance to the function of the tetrapod neck, the great diversity in the tetrapod atlas-axis complex remains poorly understood in terms of its evolutionary history. To aid in clarifying the evolutionary history of this structure across tetrapods, we survey and synthesize atlas-axis complex morphology in over 240 extant and extinct taxa. We find the atlas-axis complex varies among extant tetrapods from being composed of 8 distinct components, as in alligators and tuatara, to 2, as in mammals, birds, and squamates, to a single component in amphibians. We find that every extant tetrapod has an atlas with a morphology unique within its vertebral column. The atlantes of extant tetrapods are comprised of, at minimum, paired neural arches and a centrum, and at maximum, paired proatlases, paired neural arches, an intercentrum, and a pleurocentrum. Present in all extant tetrapod clades

besides lissamphibians, the axis is most often distinguished from more posterior vertebrae by an anteriorly-oriented odontoid process contributing to the skull–neck joint. When we investigated the evolutionary histories of atlas-axis morphology through fossil taxa, we found that the highly similar morphologies between distantly related extant groups, evolved convergently along unique pathways to arrive at similar morphologies. Furthermore, for most clades, the evolution of the atlas-axis complex is typified by a trend towards fewer components in the adult elements, with crocodylians and rhyncocephalians deviating from this trend. Integration of considerations of vertebral development with morphological conditions provides the basis for hypotheses of losses, fusions, and modifications of the atlas-axis complex, which will require detailed investigations of developmental series to be tested.

**Funding Sources** NSERC RGPIN-06442 & the Indira Gandhi Memorial Fellowship

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

## EXAMINING DIETARY DIVERSITY IN A PALEOGENE HYRAX (AFROTHERIA, MAMMALIA) FAUNA FROM THE FAYUM DEPRESSION, EGYPT USING MESOWEAR ANALYSIS

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With most ungulates absent from Africa until the Miocene, the morphologically diverse hyraxes were a major component of the Eocene-Oligocene community at Quarry L-41 (~34 Ma) in the Fayum Depression, Egypt. However, their foraging strategies are poorly understood. This study focuses on four extinct hyraxes: *Thyrohyrax meyeri*, *Thyrohyrax litholagus*, and *Megalohyrax eocaneus*, all expected to be grazers; and *Saghatherium bowni,* previously described as a browser.

Mesowear can place extinct herbivores on a spectrum from grazer to browser based on the abrasiveness of their lifetime diets. Crown height, tooth length, and cusp angle were measured for the first lower molars (M1) in these four hyrax species. Specimens were categorized into Wear Classes (WC), which correspond with developmental age. WC ranged from 1, first adult molar fully erupted, to 8, all molars extremely worn with significant dentin exposure.

Change in mean crown height and cusp angle across different wear classes was not significantly different. Nonetheless, apparent trends suggest compositional differences in diet. Change in mean crown height for *Saghertherium* indicates that it incorporated more graze than browse because M1 wear occurred in earlier WCs and increased throughout life. In contrast, less wear for WC 1 through 4 in *Thyrohyrax* indicates that it incorporated more browse. This agrees with recently collected carbon isotope data, which suggests that *Saghatherium*'s diet included more graze than *Thyrohyrax*'s. These data are consistent with the description of *Thyrohyrax* as an arboreal browser. The change in mean crown height for *Megalohyrax* also suggests a less abrasive diet, although sample size for *Megalohyrax* was smaller. The browse-biased diet for *Megalohyrax* is surprising, as isotope values suggest a more open environment. Browsing in salt-stressed environments, forest canopies or forest edges could explain these combined data. *Megalohyrax* could have foraged in a wider variety of environments than the other taxa because its larger size enabled a wider range.

By reconstructing the diets and niche partitioning among morphologically diverse hyraxes at L-41, we hope to gain insights about the ecosystem represented by L-41 near the Eocene-Oligocene Boundary (EOB). This locality represents a time of ecological dynamism when many mammalian communities were dramatically restructured, though the impact of the EOB on African mammal communities remains poorly understood.

**Funding Sources** NSF DBI 2023087

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Romer Prize Session (Thursday, October 19, 2023, 8:00 AM)

## FUNCTIONAL DIVERSIFICATION OF LUMBAR VERTEBRAE IN PALEOGENE MAMMALS

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Lumbar vertebrae morphology varies extensively across extant mammals, reflecting the evolution of different functions across a wide range of locomotor modes and body size. But when did this functional diversification begin? Though the lumbar region of mammals is known to have originated along therian stem, its subsequent diversification has been largely unexplored in the fossil record. I hypothesized that the ecological expansion of placental mammals after the end Cretaceous mass extinction resulted in functional diversification of lumbar vertebrae, and that variation increased through the Cenozoic. I compared the amount of morphological variation and correlation of morphology, body size, and locomotor mode between Paleogene placentals and extant mammals. I sampled lumbar vertebrae from 55 mammalian species: 2 non-therians, 4 extant marsupials, 27 Neogene to extant crown placentals from across 9 orders, and 22 Paleogene placentals. I used 3D geometric morphometrics to quantify lumbar shape, centrum width as a proxy for body size, and locomotor categories taken from previous literature. I found that Paleogene placentals had high variation in lumbar morphology, comparable to extant mammals. Additionally, both Paleogene and extant mammals showed the same allometric changes to lumbar shape, with centra shortening and neural spines becoming more perpendicularly oriented as body size increased. However, in taxa mammals, these changes appeared at smaller sizes compared with extant taxa. An analysis of variance (ANOVA) of locomotor category found significant correlation between lumbar shape and locomotor mode, but a discriminant function analysis (DFA) did not perform well in predicting locomotor mode from lumbar shape. Observation of the morphospace indicates that this may be due to variation of lumbar function within a single locomotor category, such as differences between in mobility across cursorial mammals. The changes in function across the morphospace instead show differences in mobility and power of back flexion based on the relative proportions of the centra and neural spines. Surprisingly, several “archaic” mammals, like the hyaenodontid *Sinopa*, showed highly mobile lumbar morphology, indicating that flexion of the back was already an important component of mammalian locomotion early in this radiation. These findings show that lumbar vertebrae diversified quickly at the beginning of the Cenozoic, evolving as a distinct functional unit within the spine.

**Funding Sources** Geological Society of America Student Grant, Paleontological Society Student Grant, the McCormick Science Grant and Galloway/Perry/Horowitz fund at the Indiana University

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Colbert Poster Prize Session

**INTEGRATING SECOND MOMENT OF AREA WITH OSTEOHISTOLOGY TO IDENTIFY LIMITATIONS OF WEIGHT-BEARING LIMB BONES**

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The second moment of area can be used to measure how well a cross-sectional area will resist biomechanical stresses and strains. Previous research used this concept, alongside musculature reconstruction, to investigate gait shifts in the hadrosaurid dinosaur, *Maiasaura peeblesorum*, and concluded that the animal underwent a permanent gait shift from bipedal juveniles to quadrupedal adults. However, this study used the cross-sectional areas of broken elements and failed to incorporate consistent sampling, ontogenetic variation, and diagenetic deformation, which are necessary to establish the biological significance of the related findings.

In our study, we used age-calibrated osteohistological sections of *Edmontosaurus annectens*, sampled from the minimum diaphyseal circumference of weight-bearing limb bones, to establish a method of calculation for their strength and structural integrity. Prior to analysis, the osteohistological images were subjected to digital retrodeformation to recover a more accurate size and shape of the sampled cross-sectional area. The images then underwent image processing to mitigate selection bias and automate the procedure of identifying cortical bone versus vascular space. Calculations for the maximum strength of compression and buckling on the X and Y axes were taken. The results indicated a large overestimation of the maximum weight each bone was able to support, corroborating with data from modern analogs. Although our study was limited to a static moment, the methods yielded the expected relationship where the compressive load was much larger than the buckling load.

Future work will seek to further limit selection bias and test this method using a dynamic moment through ontogeny. Understanding the biological meaning of the second moment of area of weight-bearing limb bones will provide data to validate previous body mass estimates and help identify the limitations of weight-bearing limb bones when subjected to biomechanical stresses and strains.

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Technical Session 15: Paleoecology & Paleoclimatology (Friday, October 20, 2023, 1:45 PM)

**THIRTY YEARS OF COLLABORATIVE VERTEBRATE PALEONTOLOGY: THE MAHAJANGA BASIN PROJECT (LATE CRETACEOUS, MADAGASCAR)**

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Much attention is currently focused — appropriately so — on neocolonialism in paleontology, so-called 'parachute science,' especially as it pertains to developing countries in the Global South. We take this opportunity to articulate our attempts to conduct collaborative science over the last 30 years of the Mahajanga Basin Project, an effort focused on the discovery and analysis of fossil vertebrates from the Late Cretaceous of Madagascar. Over the course of 14 expeditions, ~25,000 specimens have been discovered, many of them skulls and skeletons. The sample includes some of the most complete and best-preserved specimens for entire clades of vertebrates from the southern supercontinent Gondwana. Almost all major terrestrial and freshwater vertebrate groups living on southern landmasses at the time are represented: cartilaginous, lobe-finned, and ray-finned fishes, frogs, turtles, lizards, snakes, crocodyliforms, sauropod and non-avian theropod dinosaurs, birds, and mammals.

This presentation will focus on several major science-adjacent goals of the Mahajanga Basin Project:
1) To develop and maintain a robust, transparent, and mutually beneficial collaborative framework with various Malagasy governmental agencies, institutions of higher education, and individual researchers. Importantly, this has entailed the development of a series of collaboration agreements with several national government ministries and the University of Antananarivo. All fossils are collected legally, and the agreements stipulate that all holotypes and one-half of the remaining specimens must be returned to Madagascar. 2) To enhance in-country paleontological research infrastructure (this has included building a collections facility and furnishing it with specimen cabinets, as well as a classroom) and to collaborate on research endeavors. 3) To promote human resource skills development in research methods, technical expertise in the field and laboratory, and natural history collections care. 4) To collaborate with scientists and educators to advance public knowledge and science literacy on the rich paleontological heritage of Madagascar. 5) To work with local organizations and international partners on best practices for, and the implementation of, healthcare and educational efforts in rural, underserved regions of Madagascar. This has entailed building schools, hosting medical and dental missions, and development of sustainable community initiatives in our field areas and elsewhere.

**Funding Sources** National Science Foundation, National Geographic Society, David B. Jones Foundation, Stony Brook University, Denver Museum of Nature & Science, and Ohio University

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Technical Session 3: Fishes & Amphibians (Wednesday, October 18, 2023, 8:00 AM)

**SPECIMEN-LEVEL ASSESSMENT OF ONTOGENY AND PHYLOGENY OF NORTH AMERICAN METOPOSAURIDS (TETRAPODA, TEMNOSPONDYLI)**

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Despite their prevalence in Late Triassic faunas, our understanding of metoposaurid ontogeny and phylogeny remains poorly realized. In particular, little is known about small-bodied metoposaurids largely due to an absence of well-documented growth series that include early juvenile through adult specimens. This may be due to size bias such as biotic aggregation of similar sized individuals in nurseries or breeding colonies (i.e., pre-mortem) and/or that smaller elements are more likely to disperse due to abiotic factors such as water flow (i.e., post-mortem). Of the few small-bodied metoposaurid specimens that are known, most are considered to be discrete species, such as *Apachesaurus gregorii* and *Arganasaurus lyazidi*, even though they commonly co-occurred with the large-bodied "typical" metoposaurids in the southwest United States and Morocco, respectively. Polymorphisms within metoposaurid-dominated bone beds have been increasingly well-documented, and many of these polymorphisms relate to body size and are inferred as ontogenetically variable characters. However, many polymorphisms also seem to be decoupled from body size. To investigate the distribution of polymorphisms within putative populations and species of North American metoposaurids, we employ specimen-level phylogenetic analyses and morphometric analyses. Preliminary results support the validity of previously described North American species with polymorphisms represented by singletons typically recovered among a core species-level morphotype. Results also indicate that small (inferred juvenile) individuals tend to appear early-diverging within species as has been suggested for other temnospondyl clades. Regardless of the tree topology, specimen-level OTUs tend to form a stratigraphically ordered grade based on both chrono- and biostratigraphic correlations. This is suggestive of anagenetic evolution in at least one or more genera, obscuring well-resolved phylogenetic relationships. To address this, it may be necessary to develop empirical datasets of intraspecific variation within well-represented members of a clade along the lines of what we have done with metoposaurids among the Stereospondyli.

**Funding Sources** Department of Geoscience Graduate Student Fund, Friends of the Geology Museum, GSA Graduate Student Research Grant (no. 12497-19), Sherry Lesar Fund for Geological Wonder

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Romer Prize Session (Thursday, October 19, 2023, 8:00 AM)

## HISTOLOGICAL INSIGHTS INTO THE EVOLUTION OF MAMMALIAN GROWTH TRAJECTORIES FROM COMPARATIVE HISTOLOGY OF NON-MAMMALIAFORM CYNODONTS

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Within the mammalian lineage there is a longstanding hypothesis that life history patterns evolved from a highly variable and developmentally plastic growth trajectory to one that is inflexible and plateaus early in ontogeny in the immediate ancestors of crown-group mammals. However, histological evidence from traversodontids reveals a mosaic of growth patterns, leading to some discordance between evolutionary life history patterns observed along the lineage leading to mammals and those observed within cynodont side branches. For example, sustained rapid growth that plateaus at sexual/skeletal maturity is a typical mammalian growth trajectory that is echoed by some traversodontid species. However, the context of when in ontogeny this shift occurs, and whether it is constrained among a fossil population is unclear.

Using histological and body size data from four cynodont species that co-occur in the Anisian Manda Beds of Tanzania, I documented intraspecific variation in bone tissue composition throughout femoral size series to test hypotheses about the acquisition of fixed growth trajectories in the mammalian stem. Histological analyses of 36 individuals from 11 localities allowed for control of relative geologic age, geographic area, paleoenvironment, and other extrinsic factors that impact growth rates. Further, by sampling iteratively from a size range that spans ~35–100% maximum femoral length, I comprehensively assessed intraspecific histovariation within size classes to confirm or refute the presence of inflexible growth trajectories.

Histological details included bone tissue composition, degree of remodeling, presence and periodicity of growth marks, vascular density, cortical robusticity, and proportional thickness of different bone tissue types. At the population level, immature tissue types dominate. By contrast, a moderately fast paced growth trajectory that plateaus at large size is demonstrated in *Luangwa drysdalli* whereas highly variable tissue types demonstrate a decoupling of size and histological markers of maturity in *Scalenodon angustifrons*. These species are close relatives and indicate an innate biological difference in growth trajectory that cannot be ascribed to environmental conditions or body size. Further, the maintenance of moderately fast growth throughout ontogeny in *L. drysdalli* provides

evidence for an independent acquisition of inflexible growth prior to the evolution of mammals.

**Funding Sources** NSF EAR-1337569

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Technical Session 7: Birds (Thursday, October 19, 2023, 8:00 AM)

### ECOMORPHOLOGY AND MACROEVOLUTION OF THE AVIAN QUADRATE

Kuo, Pei-Chen[1], Navalón, Guillermo[1], Benson, Roger[2], Field, Daniel J.[1]

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In birds, the quadrate bone acts as a hinge between the lower jaw and the skull, playing an important role in cranial kinesis. Specifically, the quadrate directly transmits forces from the adductor muscles at the back of the skull towards the beak and lower jaw. As a result, the evolution of avian quadrate morphology has presumably been influenced by selective pressures related to feeding ecology. However, the variation of quadrate morphology in living birds and its potential relationship with ecology have never been quantitatively characterized. Here, we used three-dimensional geometric morphometrics to quantify morphological variation of the quadrate and investigate its relationship with an array of key ecological features across ~200 bird species covering all major lineages of extant birds. We found a generally weak association between quadrate shape and ecology, although the strength of this relationship varies across phylogenetic scale. Instead, other factors such as allometry and, particularly, phylogeny exhibit stronger relationships with quadrate shape. Furthermore, our results suggest that the avian quadrate evolved as an integrated unit, and also exhibits strong associations with the morphologies of neighboring bones with which it articulates. However, these associations vary in terms of their nature and strength among lineages (e.g., Telluraves versus non-Telluraves), perhaps reflecting differences in biomechanical aspects of the kinetic systems among different clades. Our results collectively suggest a more complex macroevolutionary scenario than originally envisioned in which quadrate morphology evolved jointly with other elements of the avian kinetic system, with the major lineages of birds exploring alternative quadrate morphologies. We suggest that the strong association between quadrate shape and phylogeny provides an excellent opportunity for using aspects of geometric shape to place isolated fossil quadrates in a phylogenetic context using an explicitly quantitative framework.

**Funding Sources** This work was funded by UKRI grant MR/S032177/1 to D. J. F. Additional funding for the project was provided by the ERC Starting Grant ERC-2015-STG-677774 to R.B.J.B.

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

### EXPANDING THE KNOWN VERTEBRATE RECORD OF THE MID CRETACEOUS BLACKLEAF FORMATION AND THE IMPLICATIONS FOR THE MID CRETACEOUS OF WESTERN NORTH AMERICA AS A WHOLE

Lafaye, George B., Varricchio, David J.

Earth Science, Montana State University, Greenville, South Carolina, United States

The Blackleaf Formation is a fossil bearing formation stretching through the Albian and Cenomanian stages of the Cretaceous. Fossils from the Blackleaf Formation have historically been found from terrestrial upland environments, however new fossils found in northern Montana have expanded the fossil record to include marine and estuarine fossils, including records of Chondrichthyes, Pholidosauridae, and Lepisosteiformes in a marine deposit. New microfossils from terrestrial environments have also been found and described, representing Lepisosteiformes, Nodosauria, and Charcharodontosauria, representing one of the youngest records of the latter in North America.

This addition of new groups to the faunal census of the Blackleaf Formation merits renewed looks into the faunal similarities of the Blackleaf Formation to similar formations in the mid-Cretaceous, including the Wayan (Idaho) and Willow Tank (Nevada) Formations as well as the Mussentuchit member of the Cedar Mountain Formation(Utah). Analysis of each Formation’s unique fauna through time and place allows for greater understanding of the faunal turnover that defines the mid-Cretaceous. The presence of Charcharodontosauria in the Blackleaf Formation implies that Charcharodontosauria was

more widespread in the mid-Cretaceous before their extinction in North America. This charcharodontosaurian tooth is from a similar time compared to *Siats meekerorum*, from deposits roughly 96-95.4 Ma, another connection between the Mussentuchit member of the Cedar Mountain Formation and the Blackleaf Formation. Reports of new fauna throughout the Blackleaf Formation will soon lead to mapping of fauna throughout the formation, showing how faunal assemblages change in proximity to the Western Interior Sea as it transgresses and regresses.
This project highlights the importance of further research into the Blackleaf Formation, and the importance of microvertebrate assemblages to extract key information on the diversity of fauna during the mid-Cretaceous. This research paves the way for further studies, using measured ages from porcellanite beds of the Blackleaf Formation to map changes in fauna throughout the entirety of the formation with greater precision, leading to a greater understanding of faunal turnover from the Early to Late Cretaceous in reference to the transgressing Western Interior Sea.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**REDESCRIPTION AND ANALYSIS OF THE CRANIAL ANATOMY AND PHYLOGENETIC AFFINITIES OF *PLEUROSTYLODON MODICUS*, AMEGHINO 1897 (MAMMALIA, NOTOUNGULATA)**

Lages, Sergio[1], Flynn, John J.[2], Perini, Fernando A.[1]

[1]Department of Zoology, Universidade Federal de Minas Gerais, Belo Horizonte, Minas Gerais, Brazil, [2]Division of Paleontology, American Museum of Natural History, New York, New York, United States

Notoungulata is one of the enigmatic endemic groups of mammals to evolve in isolation in South America. Despite being the most diverse and abundant group of native ungulates, their anatomy and phylogenetic relationships are not yet fully understood. They are traditionally divided into Toxodontia and Typotheria, but the position of many taxa attributed to each of these groups remains uncertain. The genus *Pleurostylodon* is, traditionally, included in the family Isotemnidae within Toxodontia, one of the oldest and most morphologically conservative members of the order. Phylogenetic evidence, however, suggests that Isotemnidae, as traditionally defined, is a paraphyletic assemblage. Since initial descriptions in the early 20th century, there have been no new extensive contributions to the anatomy of *Pleurostylodon*. We provide a complete anatomical redescription of the skull of *Pleurostylodon* in order to add new information on its cranial morphology. The anatomical descriptions were made based on specimens housed in the American Museum of Natural History and Field Museum of Natural History in the USA, and the Museo Argentino de Ciencias Naturales and Museo de La Plata in Argentina. One of the specimens, AMNH FM 28880, was scanned using 3D microCT x-ray tomography to analyze the internal anatomy of the skull. Specimen MLP 74-IV-27-1 comprises an essentially complete skull and is of great relevance as it is potentially the most complete and well-preserved individual ever found. Although it was already known and mentioned in some prior studies, there is no published description of this cranial material. Our review and analysis provided new information about the cranial roof and orbitotemporal region and also added new details about the ear region. Specimen AMNH FM 28880 preserves a notch on the nuchal ridge, also observed in *Homalodotherium,* which may be a feature that would support the inclusion of the latter in Isotemnidae. Comparison with other isotemnids also shows that *Pleurostylodon* has, in general, a more conservative cranial morphology than *Rhyphodon*, *Thomashuxleya,* and *Periphragnis*, which probably form a separate clade within Isotemnidae. This new information, together with more detailed analyses of CT scan images, will allow a more precise reconstruction of the skull of *Pleusrostylodon*, as well as provide new information for phylogenetic analyses that can contribute to better testing the monophyly of and elucidating the relationships of Isotemnidae.

**Funding Sources** National Council for Scientific and Technological Development – CNPq (422868/2016-7)
Programa de Apoio à Pós-Graduação (PROAP) — CAPES

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Technical Session 12: Methods & Paleohistology (Friday, October 20, 2023, 8:00 AM)

**TAPHONOMIC VARIATION AT MULTIPLE SCALES: TRENDS OF OCCURRENCE, MACRO- AND MICROSCOPIC CONDITION VARY PREDICTABLY ACROSS FACIES AND ALONG SURFACES OF NONDEPOSITION AND EROSION**

Laker, Rachel

Geophysical Sciences, University of Chicago, Chicago, Illinois, United States

The preservational quality and abundance of fossil bone is likely to be sensitive to rates of sedimentation: burial rate should affect the potential both for time-averaging of bone input and for its taphonomic and early diagenetic modification. For paleobiologic analysis, such taphonomic bias must be disentangled from variation produced biologically. Sequence stratigraphic analysis, which subdivides records into intervals of relatively high sedimentation rate (aggradational facies) and low net sedimentation rate (producing stratigraphic surfaces of erosion, sediment bypass or starvation) provides a framework for testing these ideas: bones along stratigraphic surfaces should tend to be concentrated and should be more time-averaged and taphonomically altered; bones in rapidly accumulated strata should be more sparse and consistently better preserved.

To test these predictions, I conducted a sequence stratigraphic analysis of the Late Cretaceous Aguja Formation in Big Bend National Park (TX, USA), building on the lithostratigraphic divisions recognized by Lehman (1985), and examined newly-collected vertebrate material for macro- and microscopic taphonomic condition. The Aguja Fm contains (1) a series of regressive shoreface (basal and Terlingua Creek Sandstone members) and delta front sands (upper shale member; yields taxonomically significant vertebrates) that reflect rapid siliciclastic accumulation; (2) a thin, marine-transgressive Rattlesnake Mountain Sandstone, which is composed of multiple heavily reworked sand layers, which culminate in (3) a hiatal, concretionary surface of maximum transgression (SMT; likely sediment starved).

Taphonomically, the prediction that abundance and preservational quality followed sequence stratigraphic position was borne out: (1) Although Terlingua Creek Sandstone shoreface sands yielded variably preserved and fragmentary bone material, the overlying deltaic sands contains bone-rich horizons with less rounding and fragmentation; these bones show mixed drying/waterlogging collagen signals with a variable, sometimes extreme, terrestrial-form microbial tunneling. (2) Bone from the Rattlesnake Mountain Sandstone show severe rounding and fragmentation, with variable staining; (3) Bones from the SMT show pyrite/iron oxide infill and staining, and although bone-rich, consist of isolated shark and fish teeth. These results attest to the important role of sedimentology in taphonomic variation at multiple scales.

**Funding Sources** This project was funded by the Society for Sedimentary Geology (SEPM) and the University of Chicago Department of Geophysical Sciences.

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Technical Session 16: Theropods - I (Saturday, October 21, 2023, 8:00 AM)

## NEW INSIGHTS INTO UNENLAGIINE (THEROPODA: PARAVES: DROMAEOSAURIDAE) DIVERSITY, PALEOECOLOGY, AND PALEOBIOGEOGRAPHY DERIVED FROM LATE CRETACEOUS FOSSILS FROM PATAGONIA AND ANTARCTICA

Lamanna, Matthew[1], Porfiri, Juan[2], Baiano, Mattia[3], dos Santos, Domenica[2], Gianechini, Federico[4], Case, Judd A.[5]

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Unenlagiine dromaeosaurids are among the most bird-like of Gondwanan non-avian theropod dinosaurs, yet the fossil record of these paravians is highly incomplete, with most taxa represented by fragmentary remains and/or separated by lengthy temporal gaps. Here we report a new unenlagiine taxon from the Late Cretaceous of northern Patagonia and reinterpret the enigmatic, similarly aged Antarctic paravian *Imperobator antarcticus* as a probable member of Unenlagiinae. The new Patagonian taxon comes from the Santonian Bajo de la Carpa Formation of the Neuquén Basin of Neuquén Province, Argentina, thereby filling a substantial stratigraphic gap in the unenlagiine fossil record. Although known only from a very incomplete postcranial skeleton, the bones of the new taxon exhibit morphological differences from

corresponding elements in other unenlagiines. Moreover, in several aspects, the humerus of the new form appears intermediate between those of geologically older unenlagiines from the Neuquén Basin (e.g., *Unenlagia* spp. from the Turonian–Coniacian Portezuelo Formation) and that of the stratigraphically younger, larger-bodied *Austroraptor cabazai* from the Campanian–Maastrichtian Allen Formation, potentially indicating a transitional stage in unenlagiine evolution. Furthermore, this humerus offers paleoecological information in exhibiting subcircular punctures near its distal end that are interpreted as feeding traces most likely left by a conical-toothed crocodyliform or theropod.
The holotype of *Imperobator* was collected from an uppermost Campanian–lowermost Maastrichtian (ca. 72 Ma) exposure of the Cape Lamb Member of the Snow Hill Island Formation on the Naze Peninsula of James Ross Island, Antarctic Peninsula. A recent phylogenetic analysis recovered this taxon as a paravian of uncertain position within that maniraptoran clade. Based in part on our study of previously undescribed material, including multiple craniomandibular fragments, we tentatively reinterpret *Imperobator* as an exceptionally large-bodied unenlagiine comparable in size to *Austroraptor*. If correct, this would extend the paleobiogeographic range of Unenlagiinae to include Antarctica—thereby enhancing the already considerable similarities between the latest Cretaceous dinosaur faunas of southern South America and the Antarctic Peninsula—and furthermore, demonstrate that unusually large unenlagiines inhabited the Gondwanan high latitudes.

**Funding Sources** MCL, US National Science Foundation (NSF) grant ANT-1142129; JDP, DDdS, Museo de Ciencias Naturales de la Universidad Nacional del Comahue; JAC, US NSF grant ANT-0003844.

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**FUNCTIONAL MORPHOLOGY OF CARNASSIAL DENTITIONS IN CARNIVOROUS MAMMALS (CARNIVORA, HYAENODONTA, DASYUROMORPHIA)**

Lang, Andreas

Institute of Geosciences, Rheinische Friedrich-Wilhelms-Universität Bonn, Bonn, Germany

Carnassial teeth, specialized for slicing meat, evolved multiple times in mammalian evolutionary history. I compared the form and function of the lower carnassials of eutherian Carnivora (m1) and Hyaenodonta (m1 – m3), as well as of the metatherian Dasyuromorphia (m2 – m4) using virtual 3D models based on µ-CT scans. A virtual reconstruction of the chewing cycle with the Occlusal Fingerprint Analyser (OFA) software revealed a general functional simplification with increasing carnassialization. The crushing function is reduced, and in some taxa a secondary shearing and guiding function is performed by the trenchant talonid. In the dasyuromorphs and hyaenodonts, which have multiple carnassials per tooth row, the individual carnassial teeth successively occlude from distal to mesial. A dental topographic analysis (DTA) for computing the crown curvature and using the ariaDNE algorithm shows that the morphology of carnassial teeth is getting less complex, as the crown curvature decreases with progressing carnassialization. This is due to the reduction of cusps and crests in more carnassialized teeth. A 3D geometric morphometric analysis (GMM) demonstrated for all studied clades a general trend of carnassial blade enlargement and talonid basin reduction with increasing carnassialization. These observations point to a general trend of convergent evolution, which results in similar functional and structural simplifications of carnassials. The GMM additionally points to a divergent unique trend of carnassialization within the Carnivora. In caniforms and feliforms with weakly carnassialized teeth, the lower carnassial (m1) is longitudinally elongated with an enlarged carnassial cutting blade and a talonid crushing basin. Thus, besides the highly effective carnassial cutting function, multifunctionality is retained. A reconstruction of the hypothetic ancestral state suggests that this represents the plesiomorphic carnivoran condition. This carnassial type provides a high adaptive versatility and enabled the evolution of highly specialized meat-eaters as well as a wide range of other ecomorphotypes in Carnivora. In the hypercarnivorous Hyaenodonta with predominant cutting function and greatly reduced crushing function, the dietary adaptive potential was much lower which may have contributed to a a loss of diversity and subsequent extinction of the group in the Miocene.

**Funding Sources** Studienstiftung des deutschen Volkes

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Technical Session 10: Euarchontoglires & Xenarthra (Friday, October 20, 2023, 8:00 AM)

## VARIATION IN ENDOCRANIAL SHAPE ALLOMETRY WITHIN EUARCHONTOGLIRES

Lang, Madlen[1], López Aguirre, Camilo[1], Schroeder, Lauren[2], San Martin Flores, Gabriela[1], Bertrand, Ornella C.[3], Silcox, Mary T.[1]

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Geometric morphometrics using 3D landmark data provides a framework to examine variation in endocranial morphology and the mechanisms underlying diversification. The goal of this study is to characterize endocranial shape among major clades of Euarchontoglires and examine the impact of allometry, which is critical for mapping trajectories of evolutionary change within the group. The digital brain endocasts of 140 species of extant Euarchontoglires were landmarked with 28 fixed landmarks and 8 semi-landmarks. The sampling regime was intentionally designed to facilitate the addition of incompletely preserved fossils. Principal component analyses on Procrustes shape variables show a clear phylogenetic and allometric pattern in endocranial variation. Analysis of morphological disparity found rodents to be the most diverse in endocranial shape followed by haplorhines, strepsirrhines, lagomorphs, scandentians and dermopterans. A phylogenetic regression of shape and log centroid size with clade as a covariate suggests different allometric trajectories among clades ($R^2 = 0.03$, $p = 0.002$). Phylogenetic regressions of shape and size performed on separate transformations of each clade found a significant impact of size on shape for haplorhines ($R^2 = 0.17$, $p = 0.001$) and rodents ($R^2 = 0.03$, $p = 0.01$). Visualisation of wireframe warps of fitted values of PC1 suggests that for haplorhines, increasing size is primarily associated with a larger neocortex, and for rodents increasing size is associated with a wider circular fissure. Integration tests found endocranial shape to be the least integrated in rodents and highly integrated in haplorhines. The low levels of integration observed for rodents may be associated with a weaker allometric effect. Rodents are among the most ecologically diverse mammals and the relaxation of allometric constraints with respect to the shape of the brain may have facilitated this diversification. In contrast, the higher levels of integration within haplorhines, possibly associated with the stronger impact of allometry, indicates that adaptive changes in endocranial shape within this group may have occurred along an allometric line of least resistance. In sum, these results suggest fundamental differences in how shape and size covary among euarchontoglirans, highlighting the importance of a multi-faceted approach to understanding brain evolution in the group.

**Funding Sources** Supported by NSERC discovery grant to MTS; Ontario Graduate Scholarship to MML; H2020-MSCA-IF-2018-2020 792611 to OCB.

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Technical Session 13: Fishes - Actinopterygians (Friday, October 20, 2023, 1:45 PM)

## NO JAWS? NO PROBLEM. MORPHOLOGICAL DIVERSITY IN THE FEEDING APPARATUS OF HETEROSTRACANS JAWLESS “FISHES” (AGNATHA: HETEROSTRACI)

Lanzetti, Agnese[1], Dearden, Richard[2], Jones, Andrew S.[1], Giles, Sam[1], Lautenschlager, Stephan[1], Johanson, Zerina[3], Randle, Emma[1], Sansom, Ivan J.[1]

[1]Geography, Earth and Environmental Sciences, University of Birmingham, London, United Kingdom, [2]Biodiversity Center, Naturalis, Leiden, Netherlands, [3]Earth Sciences, Natural History Museum, London, United Kingdom

The evolution of the jaw marks a dramatic shift in vertebrate evolution, but, before that, jawless forms diversified and dominated the Paleozoic environments. Heterostracans are a morphologically diverse group of heavily armored, jawless stem-gnathostomes that were a major component of marine ecosystems globally in the Silurian and Devonian. Understanding the functional and morphological diversity of these early jawless vertebrates can provide key insights into the evolution and development of modern vertebrate morphology and feeding modes. In this project, we aim to characterize the anatomical and functional diversity of heterostracans by analyzing 3D preserved complete fossils with high-resolution CT scanning. We digitized over 20 specimens spanning the morphological and phylogenetic diversity of the group. By reconstructing the anatomy of the oral region, we were able to identify evolutionary patterns

and polarize the character evolution in the group. We delimit three main functional groups based on the number and morphology of the oral and post-oral plates. The multi-plated forms have more than 10 oral plates articulated with a post-oral plate on the ventral surface. These forms likely represent the ancestral state of the group and are found across the evolutionary tree, from the late diverging Pteraspidiformes to the earlier diverging Cyathaspidae. In this second group, we also found two additional forms, showing a progressive reduction in plate number and complexity: *Anglaspis*-like forms, which have a reduced post-oral plate in the center and 2-3 elongated oral plates on each side, all directly in contact with the ventral shield, and *Poraspis*-like forms, which only have an enlarged post-oral plate with small accessory plates on the side. These variety of morphologies points to these animals occupying a variety of feeding niches and environments. Though, the morphology of the articulation between the plates suggested a limited range of movement, potentially indicating they all performed some measure of microphagous filter feeding. Future qualitative geometric morphometrics and phylogenetic analyses will allow us to test this hypothesis on character evolution and examine more in detail the potential feeding strategies of these enigmatic early vertebrates.

**Funding Sources** Leverhulme Grant RPG-2021-271 “Feeding without Jaws”

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**FIRST OCCURRENCE OF *GARGOYLEOSAURUS* (DINOSAURIA: ANKYLOSAURIA) IN UTAH; THE IMPORTANCE OF OSTEODERMS FOR THE PURPOSE OF TAXONOMY**

Large, Daniel S.

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Ankylosaurs are a group of armored dinosaurs that likely evolved sometime during the Middle Jurassic period and survived until the extinction of all non-avian dinosaurs at the end of the Cretaceous period. Ankylosaur material from the Jurassic is rare, and often fragmentary, leading to confusion about the phylogenetic placements of various Late Jurassic and Early Cretaceous taxa. A new specimen of a Late Jurassic (Tithonian) ankylosaur from the Hanksville-Burpee Dinosaur Quarry near Hanksville, Utah is the first occurrence of the genus *Gargoyleosaurus* in the state and serves as a case study for the potential taxonomic utility of dorsal osteoderms in ankylosaurs. Dorsally placed osteoderms appear to display variation which is more taxonomically useful than previously thought and may allow for previously undiagnosed ankylosaurian material to be more directly compared and diagnosed to previously described taxa.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**FIRST RECORD OF TURTLE EGGS FROM THE UPPER CRETACEOUS NANAIMO GROUP OF VANCOUVER ISLAND, BRITISH COLUMBIA, CANADA**

Larson, Derek W.[1], Arbour, Victoria[1], McLachlan, Sandy[2]

[1]Royal BC Museum, Victoria, British Columbia, Canada, [2]Earth & Environmental Sciences, University of Minnesota, Minneapolis, Minnesota, United States

Terrestrial sediments of the Nanaimo Group of Vancouver Island and the Gulf Islands of British Columbia, Canada, were deposited during the Turonian to Maastrichtian in the forearc Georgia Basin between western North America and the Wrangellia Terrane. The Trent River Formation of the Comox Sub-Basin was deposited in tidal flat, delta, beach-shoreface, storm-dominated shelf, and fully marine palaeoenvironments during the Late Santonian to Early Campanian (~84 to 80 Ma), and a variety of marine reptiles including turtles, plesiosaurs, and mosasaurs have been recovered from the unit. Here we report the first occurrence of a fossil turtle egg from the Nanaimo Group, which is also the first occurrence of a fossil turtle egg from North America outside of the Western Interior Sedimentary Basin.

The egg is spherical but with slight compression from post-depositional deformation. It measures 31.35 mm in diameter along its longest axis. The shell is chalky, white, and, in several locations, weathered. The interior of the egg is mudstone-filled. Where well preserved, the eggshell outer surface is smooth but subtly undulating with rare pore openings. The shell is about 0.6 mm in thickness. A fragment of shell displaced inward from the surface has a vitreous luster and may represent the original non-diagenetically modified aragonite composition of the shell.

Turtles previously identified from the Trent River Formation include a protostegid with mandible, limb, and shell material tentatively referred to *Desmatochelys lowi*, an indeterminate panchelonioid mandible and vertebrae, and a trionychid costal plate likely from the Trent River Formation but possibly from the underlying Comox Formation. Additional undescribed turtle material has also been collected from the Trent River Formation. The size, shape, and shell thickness of the egg is consistent with (but slightly smaller than) the morphology of both *Desmatochelys padillai* and *Adocus* sp. eggs. Although a precise taxonomic identification is not yet possible, the egg can still be identified as *Testudoolithus* oosp. and, until more of the fossil turtle assemblage of the Nanaimo Group is known, can be considered to likely come from *Desmatochelys lowi* based on the similarity of features to *Desmatochelys padillai* and the known cooccurring taxa from the formation.

**Funding Sources** This work is supported by the Royal BC Museum.

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

### PRESERVING FOSSIL RESOURCES: AN ELEGANT SOLUTION FOR THE PUBLIC AND PRIVATE SECTOR

Larson, Peter L.

Vertebrate Paleontology, Black Hills Institute of Geological Research, Hill City, South Dakota, United States

Many researchers are reluctant to publish on privately held fossils, for fear that the specimens might someday “disappear”, or otherwise no longer be available for study and research verification. Other researchers argue that privately held specimens represent critical data that is too important to ignore. These specimens are often the only examples of important taxa, unique preservation, anatomical details, unrepresented ontogenetic stages, or other important data points. These researchers also argue that no specimens are truly “safe”, even if they are in public or state-controlled institutions. They point to events like the 2018 fire in Brazil that destroyed the National Museum, the losses of type specimens during WWII, thefts, sales of university held collections, etc.

Here we examine two case studies of important privately held specimens: a *Tyrannosaurus rex* skeleton (BHI-3033) and a skeleton of *Archaeopteryx* cf. *lithographica* (WDC-CSG-100) and discuss ways that data from these specimens has been preserved so that any researcher may readily access these specimens for study, even if the original should be lost or destroyed. Molding and casting, color surface scans, CT scans, XRF scans, etc., along with the use of multiple repositories, provide a modern solution to preserving important specimens and allowing greater access to researchers. Utilizing these methods would preserve data not only for those fossils that are held in private collections, but is also recommended for type, figured, and other important fossils held in public institutions.

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Preparators' Poster Session (Thursday, October 19, 2023, 4:30 - 6:30 PM)

### INNOVATIVE TECHNIQUES IN PALEO RECONSTRUCTION: A CASE STUDY OF TWO SKULLS

Lash, Catherine, Lutz, Christina
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-WITHDRAWN-

Many specimens in museum collections are incomplete by nature; either the entire specimen was not collected, or portions eroded away before collection occurred. For display specimens, partial skeletons can be difficult for the visitor to interpret, especially if a ‘skeletal map’ is not provided with the display. Traditionally, plaster was used to sculpt missing parts of a specimen; this medium can be challenging to sculpt, is not easy to control, and heavy when finished. Reconstruction of two skulls, *Arsinoitherium zitteli* (YPM 30546) and *Poposaurus gracilis* (YPM 57100), employed noteworthy methods to create a fully detachable partial skull and a complete skull from only fragmented information of the animal’s cranial morphology. While 3D printing is an excellent way to display reconstructions for exhibit, it relies on actual specimen surface data, of which, there is little known. For several specimens in the Yale Peabody Museum (YPM) renovation project, reconstruction of missing portions of the skeletons were achieved by sculpting with a two-part epoxy putty (Magic-Sculpt). After much research and consultation concerning the basic size and shape of these two skulls, the substructures were constructed utilizing lightweight materials and covered with an epoxy putty shell. The substructure of the *Arsinoitherium* is composed of expandable foam (Smooth-On Foam-iT!) and the *Poposaurus* using aluminum armature wire and foam clay (Foam-Mo); this kept the sculptures light weight and allowed for relatively easy sculpting around the substructure. The wire and foam clay also allowed the paleontologist to manipulate the basic shape before it fully dried and became more rigid. With the basic shape of the skull in place, both skulls were then encapsulated in a thin layer of epoxy putty. The epoxy putty shell, which can be sculpted like a clay, is hard enough when cured, to be further manipulated creating more detail by reductive and additive sculpting (sanding or adding putty). All YPM specimen epoxy putty prosthetics are attached to the bone surface with an archival adhesive so it can be removed if needed. Because of the large size of the *Arsinoitherium*, magnets were also embedded in the epoxy putty around the bone-sculpture boundary for easier removal. The sculpted portions of the specimens on exhibit are purely there to enhance and complete the visitor experience of the exhibited fossil animal without taking away or covering the real fossil material.

-WITHDRAWN-

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Virtual Posters

**ORBIT SIZE AND ESTIMATED EYE SIZE AND THEIR IMPLICATIONS FOR VISUAL CAPABILITIES IN DINOSAURS AND OTHER ARCHOSAURS**

Lautenschlager, Stephan

School of Geography, Earth and Environmental Sciences, University of Birmingham, UK, Birmingham, United Kingdom

Vision is one of the most important senses for animals allowing them to interact with their environment and with further implications for evolutionary histories. However, relevant soft-tissues, such as the eye and associated structures, are not preserved in fossil vertebrates limiting our knowledge of their visual capabilities. For this study, absolute and relative orbit size for ca. 400 species of dinosaurs and other archosaurs were quantified using measurements of the preserved skeletal elements as a proxy for visual capabilities. Results demonstrate that the orbit makes up on average 20% of skull size with a strong and consistent correlation across all sampled groups. This trend is largely independent of temporal distribution, species richness and phylogeny. In fact, relative orbit size is narrowly constrained and did not surpass 45% of skull size suggesting physiological and functional controls. Estimated eye size was found to be absolutely larger in herbivores, whereas carnivores tended to have smaller eyes absolutely and compared to skull size. Relatively larger eyes only occurred in small-bodied species and vice versa.

While large eyes have traditionally been hypothesized to correlate with predatory behavior to aid in hunting, the occurrence of large eye sizes in different dietary guilds implies a more general adaptation. Herbivores foraging for nutrient-rich vegetation using primarily visual cues will benefit from good sensory acuity as well. Large eyes in both carnivorous and herbivorous species could, therefore, have been an adaptation to hunting and foraging in low-light conditions as found in some modern bird species and to maximize resource utilization. However, eye size alone was not sufficient to discriminate between different activity patterns or to characterize visual capabilities in detail.

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Colbert Poster Prize Session

**PHYLOGENETIC RELATIONSHIPS OF A NEW SMALL NEOSUCHIAN CROCODYLIFORM FROM THE EARLY CRETACEOUS CLOVERLY FORMATION OF MONTANA**

Leaphart, Daniel R.[1], Pierce, Stephanie E.[2], Brochu, Christopher A.[1]

[1]Earth and Environmental Sciences, University of Iowa, Iowa City, Iowa, United States, [2]Organismic and Evolutionary Biology, Harvard University, Cambridge, Massachusetts, United States

Eusuchian crocodyliforms are traditionally diagnosed by procoelous vertebrae and an internal choana fully enclosed within the pterygoids, but recent phylogenetic analyses have recovered taxa lacking some of these diagnostic features, particularly the pterygoid-bound choana, within Eusuchia. To help resolve this inconsistency, we report a new crocodyliform from the Early Cretaceous Cloverly Formation of Montana. It is represented by a nearly complete diminutive skull and other referable fragmentary material. This skull bears a striking similarity to both *Theriosuchus pusillus* and *Wannchampsus kirpachi*, and is approximately 62 millimeters long, with a secondary choana bound anteriorly by the palatines and laterally and posteriorly by the pterygoid, as well as a compound palpebral comprised of a large anterior and a small posterior element. The skull is from an adult individual, which would have likely been around 1 meter long. Additional cranial material was found associated with procoelous vertebrae.

A maximum parsimony analysis recovers this crocodyliform as closely related to *W. kirpachi* basal within Paralligatoridae. This new taxon can be diagnosed by the following autapomorphies: anteriorly diverging nasals, and transversely expanded prefrontal pillars. This form emphasizes the disassociation of procoelous vertebrae and pterygoidal choanae at the root of Eusuchia. Moreover, it reinforces the concept that early eusuchians were small and outwardly resembled modern smooth-fronted caimans (*Paleosuchus*) and dwarf crocodiles (*Osteolaemus*), suggesting that the semiaquatic ambush predators that dominate modern crocodylian diversity arose from small, less-aquatic ancestors.

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Technical Session 15: Paleoecology & Paleoclimatology (Friday, October 20, 2023, 1:45 PM)

**EXPLORING REPRODUCTIVE OUTPUT ALLOMETRY AND POTENTIAL GROWTH AND MAINTENANCE TRADE-OFFS ACROSS EXTANT TETRAPOD GROUPS: A COMPARISON WITH NON-AVIAN DINOSAURS**

Lechki, Stephanie C.[1], Benson, Roger B.[2]

[1]Earth Science, University of Oxford, Oxford, United Kingdom, [2]American Museum of Natural History, New York City, New York, United States

Reproductive output scales with adult body mass and this relationship varies among tetrapod groups, both living and extinct. Understanding this relationship is important because it directly influences population demographics and can aid in reconstructing past ecosystem dynamics dominated by biologically distinct groups such as dinosaurs. Reproductive output traits, including clutch mass, egg/neonate mass, and clutch size, may be influenced by other growth and maintenance traits, such as relative brain mass (developmental cost hypothesis) and metabolic rates (maternal energy hypothesis). These have been proposed mainly to explain variation in viviparous mammals, with little investigation of the applicability of these hypotheses across tetrapods, or ability to explain patterns seen in extinct groups such as dinosaurs. We assembled data on adult body mass and reproductive output for 2844 living species across mammals, birds, squamates, turtles, crocodylians, and dinosaurs. We used PGLS to compare the scaling relationships of clutch mass, egg/neonate mass and clutch size across tetrapod groups, and the influence of various factors that have been proposed to influence the trade-off between clutch size and egg/neonate mass, including relative brain mass and relative basal metabolic rate. Dinosaur clutches consist of large counts of small individual offspring, similar to reptiles, especially crocodilians. This indicates that bird-like scaling of reproductive output evolved relatively late on the bird stem-lineage. Although birds have been used as analogs for dinosaur reproduction, dinosaurs differ in increasing clutch size with body mass whereas birds show no relationship (in precocial birds) or a negative relationship (in altricial birds, and seen in mammals). We find a weak, negative correlation between BMR and clutch mass in reptiles ($N = 81$, $R^2 = 0.078$, $p = 0.006$), when correcting for body mass using residuals. However, we find no such relationships for egg mass or clutch size in reptiles, or for any of measures of reproductive output for birds or mammals. Correlations between reproductive outputs and residual brain mass are absent for all groups. Therefore, we reject the universality of developmental cost and maternal energy hypotheses as general explanations of variation in the scaling relationships of reproductive output across tetrapods, meaning that we cannot currently explain the occurrence of large clutches of small individual offspring in dinosaurs.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**MESOTHERIID NOTOUNGULATES FROM A NEW DESEADAN LOCALITY IN SW BOLIVIA**

Lehr, Skye[1], Velazquez, Helen[1], Anaya, Federico[2], Shockey, Bruce J.[1]

[1]Biology, Manhattan College, Bronx, New York, United States, [2]Geology, Universidad Autónoma Tomas Frias, Potosí, Potosí, Bolivia, Plurinational State of

The goal of this project is to document a poorly known fossil locality in SW Bolivia that appears to be of Deseadan South American Land Mammal Age (Late Oligocene). Polulos is located at 21° 25.796' South, 66° 35.237' West in the Sud Lípez Provincia, in the Departamento de Potosí. It lies 11 km northeast of the Quechuan pueblo of Polulos and 2 km SSE of a distinctive fortress-like geological feature whimsically known as the "Enchanted City" (*Ciudad Encanto*). Fossils are scarce at Polulos, but remains of two species of mesotheriid notoungulates are instructive and are discussed below. These are curated in the research collection of the Universidad Autónoma Tomás Frías (UATF) in Potosí, Bolivia. Specimen UATF-V-000125 is of a large mesothere that preserves much of the rostrum and associated mandibles with nearly complete, but badly abraded, dentitions. Still, several details are discernable. Differences between UATF-V-000125 and all other known mesotheriids include gliriform I2 that is larger than the I1 and upper cheek teeth with distinctive cingulae. UATF-V-000125 (a jaw with left i1, i3-m3 and right m1-3) represents a second mesotheriid species of Polulos. Whereas UATF-V-000125 is distinctly different from other known mesotheres, UATF-V-000105 lacks any significant differences from comparative specimens of *Trachytherus alloxus*, a species otherwise known only from Salla, Bolivia. The presence of *T. alloxus* at Polulos extends the known range of the taxon and suggests a Deseadan age for the locality. The generically distinct larger species of Polulos (UATF-V-000125) raises the number of early diverging mesotheriids in the Deseadan at the Bolivian Orocline region to at least five species. The other taxa include *T. spegazzinianus* at Lacayani, Bolivia and probably at Moquegua, Peru; *T. ramirezi* also from Moquegua; *T. subandinus* from Río Pluma, Bolivia; and *T. alloxus* of Salla and Polulos. This diversity is noteworthy, since there is but a single mesotheriid recognized from the rest of South America during the Deseadan and none are known from the Eocene. The diversity in the Deseadan at the Bolivian Orocline region supports the hypothesis that mesotheriids had their initial radiation at that time and place. A secondary radiation occurred in the region later (early Miocene). This involved Mesotheriinae mesotheriids, with all the early diverging forms (i.e., "*Trachytherus*" species) going extinct by the end of the Deseadan.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**THE RETURN OF THE MUMMY: HOW EOCENE FROG MUMMIES FROM THE QUERCY PHOSPHORITES (SW, FRANCE) SHED LIGHT ON AN EUROPEAN PRESENCE OF AN AFRICAN CLADE**

Lemierre, Alfred

CR2P, MNHN/Sorbonne Université/CNRS-UMR7207, Paris, France

The Quercy Phosphorites are assemblages of hundreds of sites located in Southwestern France, ranging from the Lower Eocene up to the Miocene. First exploited for phosphates in the Nineteenth century, hundreds of vertebrate fossils were soon discovered. Although the industrial exploitation is long over, scientific projects and digs are still ongoing, with thousands of fossils now collected. These fossils are assigned to a variety of clades (arthropods, birds, amphibians, turtles, crocodilians) but mammals of all sizes constitute the majority of the fossils and diversity. Thus, the Quercy is now considered a major site for the evolution of European fauna during the Eocene and Oligocene. Anurans are present within the Quercy, known mostly from hundreds of fragmentary bones, making any taxonomic attribution and phylogenetic analyses difficult. As such, a single taxon, *Thaumastosaurus*, has been named after Quercy specimens.

However, in the early stages of the industrial exploitation (1873), several exceptional amphibian specimens were discovered with the external surface of the unmineralized tissues preserved. These specimens were commonly referred to as mummies. Unfortunately, analyses and comparisons of these mummies to fossils were impossible. Since 2012, the mummies started to be scanned, revealing preserved internal soft tissues and articulated skeletons. As such, the mummy of *Rana plicata* was assigned to *Thaumastosaurus*. When the second mummy, an articulated skeleton previously identified as *Bufo servatus*, was identified its osteological characteristics were similar to the first scanned anuran "mummy", although it represents a different ontogenetic stage. These two mummies provide essential information on the postcranial elements of *Thaumastosaurus*, known only by cranial bones. This new anatomical information was used to test the phylogenetic affinities of *Thaumastosaurus*, previously considered close to South American frogs, then later to Afro-Asian taxa. The phylogenetic analyses proposed *Thaumastosaurus* as a Pyxicephalidae, a clade endemic to sub-Saharan Africa. *Thaumastosaurus* thus represents both the oldest occurrence of this clade in the fossil record and the first occurrence outside of Africa. Its presence in Europe highlights a faunistic exchange with Africa during the Eocene and the presence of an African component in European herpetofauna before the environmental changes of the Eocene-Oligocene transition.

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Technical Session 3: Fishes & Amphibians (Wednesday, October 18, 2023, 8:00 AM)

**COMPARISON OF THE LATERAL LINE TUBULES OF TETRAPODOMORPHS FROM THE RED HILL LOCALITIES OF NEVADA AND PENNSYLVANIA**

Leong, Derrick M., Liu, Juan

Department of Integrative Biology & University of California Museum of Paleontology, University of California, Berkeley, Berkeley, California, United States

The lateral line system is a mechanosensory system in fishes that utilizes neuromasts to detect changes in environmental hydrodynamic stimuli. Bone-associated lateral line canals and tubules (minute extensions of the lateral line canal) are often preserved in fossilized dermal bones. Red Hill, Nevada and Red Hill, Pennsylvania are two localities which have produced tetrapodomorph fossils with observable lateral line structures from the Middle Devonian (late Givetian) and the Late Devonian (Fammenian), respectively. We examined the cephalic lateral line canal and tubule patterns of skulls and disarticulated dermal bones from the Nevada locality (UCMP 117884, 118283, 118605, 190999 and KUVP 94040, 158454-158457) and compared them with photographed tetrapodomorph specimens from the Pennsylvania locality (ANSP 23295, 21157, 23913). The Nevada specimens consist of abraded dermal bones, as well as three-dimensionally preserved skulls with lateral line canals and tubules, that were observed under the microscope and segmented from Computed Tomography (CT) scans. Both the exposed and structurally-intact tubules yielded similar patterns amongst all the Nevada specimens, characterized by numerous individual extensions with few bifurcations. Furthermore, the tubules of a dipnomorph specimen found in the Red Hill, Nevada locality (KUVP 93044), contained multiple fragments showing similar tubule patterns. Conversely, images of the tetrapodomorph specimens (*Hyneria lindae* and *Langlieria radiatus*) from the Red Hill, Pennsylvania locality display fewer individual tubules but are all extremely bifurcated and interconnected with one another. It is striking that similar tubule patterns appear in distantly related taxa within the same locality, as opposed to more related taxa across localities. This trend might be related to or a result of the hydrodynamic regimes of different paleoenvironments, as the Red Hill, Nevada locality represents an open marine, continental shelf, while the Red Hill, Pennsylvania locality represents a brackish or freshwater delta and alluvial plain. Examination and expansion of tetrapodomorph material and CT data is necessary to determine whether there are distinct tubules in different and convergences in similar paleoenvironments. This will aid in developing a comparative framework that will provide insight into what aspects of the tubules, and the lateral line system as a whole, change in relation to the environment and amongst different taxa.

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**DID PHYTOSAURS SWEEP LIKE GHARIALS OR SHAKE LIKE GATORS?: A PRELIMINARY COMPARISON OF PHYTOSAUR AND CROCODYLIAN VERTEBRAL COLUMNS WITH IMPLICATIONS FOR PHYTOSAUR FEEDING MODES**

LePore, Caleb N.[1], McLain, Matthew A.[2]

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Phytosaurs are an extinct group of archosauriform reptiles found in Upper Triassic deposits around the world. They are extremely similar in general morphology to crocodylians, especially the Indian gharial, *Gavialis*. Most phytosaur research has concentrated on their relationships and cranial morphology, leaving much to be explored in their postcranial anatomy, especially the vertebral column. The vertebral column plays a critical role in terrestrial locomotion, axial swimming, and head movement in feeding, making it an important target for understanding the nuances of phytosaur paleobiology. We compared the vertebral column of phytosaurs to extant crocodylians in order to test whether phytosaur vertebrae differ substantially from those of crocodylians. We utilized five linear measurements and three angle measurements to compare the vertebrae of the phytosaur genera *Smilosuchus* and *Machaeroprosopus* to published data on crocodylian vertebrae. Overall, our results show a predictable similarity between phytosaurs and crocodylians. However, we also noted striking differences. First, the centrum height-width ratio in phytosaur vertebrae is greater than in crocodylians. Phytosaur centra also vary less in their length-width ratio along the column than in crocodylians. These patterns are likely due to phytosaurs having a larger body size. The shorter centra of *Smilosuchus* or *Machaeroprosopus* compared to *Gavialis* suggests that these genera may have been less aquatic than *Gavialis*. Second, the relative length of the neural spine in the cervicals of phytosaurs is more similar to *Alligator* than to *Gavialis*. Taller cervical spines indicate greater area for the attachment of several head dorsiflexor muscles, indicating head dorsiflexion may have been more powerful in phytosaurs than in *Gavialis*. The evidence for dorsoventral movement of the head and neck in phytosaurs is consistent with prior suggestions that the bladelike posterior maxillary teeth of certain phytosaurs were used to tear off chunks of prey during forceful retraction of the head and body. Additionally, the taller neural spines in phytosaurs may have increased passive stiffness of the intervertebral joints, limiting lateral flexion of the neck and prohibiting them from engaging in feeding by lateral head sweeping as in *Gavialis*. Nevertheless, like *Gavialis*, the larger angle of the zygapophyses at the C2-C3 joint in phytosaurs may have allowed for more lateral flexibility in the anterior part of the neck.

**Funding Sources** This work was partially supported by NSF/GSA Graduate Student Geoscience Grant # 13175-21, which is funded by NSF Award # 1949901.

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Technical Session 14: Crocodylomorphs & Turtles (Friday, October 20, 2023, 1:45 PM)

**NEW MATERIAL FROM THE LOWER PALEOCENE (EARLY DANIAN) DENVER BASIN FILL GAPS IN THE PERSISTENT RECORD OF EUSUCHIA (CROCODYLOMORPHA) AFTER THE CRETACEOUS–PALEOGENE MASS EXTINCTION**

Lessner, Emily, Petermann, Holger, Lyson, Tyler

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The North American eusuchian fossil record through the Cretaceous–Paleogene (K–Pg) mass extinction is remarkable in that it indicates there is not a decrease in survivorship across the K–Pg boundary, but instead shows an increase in diversity through to the Early Eocene. Despite the group’s uninterrupted existence, gaps remain in the record of the clade, particularly near the K–Pg boundary and in Colorado. Two new eusuchians from the lower Paleocene Denver Formation of Corral Bluffs are represented by over a dozen specimens. We identify one of these specimens as a globidontan alligatorine by its globular posterior dentition and blunted rostrum. The other is tentatively identified as a *Borealosuchus* based on shape of the suborbital fenestra, proportions of the surrounding cranial elements, and a flat profile in lateral view. However, robust phylogenetic analysis is necessary before supporting assignment to specific clades. Regardless of precise taxonomic assignment, the alligatorine is the earliest known alligatorid, with diagnostic crania from the Puercan 2 North American Land Mammal Age (NALMA) and referred globular teeth from the Puercan 1 NALMA. In addition, the alligatorine is a new representative of a portion of the crocodylian phylogeny that remains largely unresolved, and its addition has the potential to resolve relationships of taxa historically referred to the wastebasket taxon ‘Allognathosuchus,’ such as *Allognathosuchus*, *Wannaganosuchus*, and *Navajosuchus*. The *Borealosuchus* morph fills both geographic and temporal gaps in the record of this clade as the first specimen from the earliest Paleocene of Colorado. Because of uncertain phylogenetic placement of the genus *Boreaosuchus* within Eusuchia, an additional specimen will increase resolution of early members of crown Crocodylia. The distinct rostral morphologies and dentition of these two taxa suggest niche partitioning in this Early Paleocene ecosystem with the alligatorine focusing on durophagy and the *Borealosuchus sp.* morph living as a generalist macrocarnivore. The persistent eusuchian record through the K–Pg mass extinction and the diversity in forms indicates that biotic recovery of prey items required to support two large, freshwater, apex predators occurred within ~500,000 years after the K–Pg mass extinction event.

**Funding Sources** Lyda Hill Philanthropies, National Geographic Society, David B. Jones Foundation

Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

## ADDITIONAL RECORD OF CAPYBARAS ON THE TEXAS GULF COAST

Lewis, Patrick J.[1], Jenkins, Kelsey M.[2], Flores, Deanna[3], Godwin, William[1], Bell, Christopher J.[4]

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Capybaras were first reported in the fossil record of the United States by Joseph Leidy in 1853 and were subsequently documented in Late Pleistocene faunas along the Atlantic coast of Virginia, South Carolina, and Georgia, and along the coast of the Gulf of Mexico in Florida and Texas. Records of the group from west of the Gulf Coast are rare, but now extend to San Diego County, California. In Texas, the few reported localities include the Aransas River site in San Patricio County, O'Brian Ranch in Bee County, Pelican Island in Galveston County, and High Island in Jefferson County. Most of those records consist of tooth fragments or partial dentitions in fragmentary dentaries or maxillae. We report two new specimens of *Neochoerus aesopi* recovered from McFaddin Beach in Jefferson County, Texas, housed at the Sam Houston State University Natural Science and Art Research Center. Both specimens are isolated left dentaries that are in relatively poor condition. Incisors and cheek teeth are preserved in both specimens, although they are broken off at or near the alveolar surfaces. Details of mandibular anatomy are largely obscured, but CT scans reveal important features of the teeth. Both specimens preserve part of the mandibular symphysis. One specimen is approximately 20 cm in total preserved length, the other 18 cm. Both are heavily mineralized and most surfaces are covered with encrusting invertebrates, or the scars left by encrustation, especially by barnacles. The preservation is in stark contrast to that of a right dentary from High Island, a bit farther southwest along the coast. The specimen from High Island is beautifully preserved, free of encrustation, and is not heavily mineralized. The specimens from McFaddin Beach and High Island support the hypothesis that these secondarily-deposited beach specimens are sourced from different primary deposits from unknown locations offshore. The age of the capybara specimens is not certain, but fossils from McFaddin Beach include numerous specimens of extinct Late Pleistocene mammals, and we accept that as the tentative age of the specimens. Capybaras were clearly a part of the Texas fauna in the past, and presumably in the Late Pleistocene, but the record remains sparse and there is much yet to be learned about them.

Technical Session 12: Methods & Paleohistology (Friday, October 20, 2023, 8:00 AM)

## BONE HISTOLOGY REVEALS PUBERTY IN A MESOZOIC REPTILE

Li, Qiang[1], Liu, Jun[2], Klein, Nicole[1], Nakajima, Yasuhisa[3], Sander, Paul Martin[1]

[1]Institut für Geowissenschaften, University of Bonn, Bonn, Nordrhein-Westfalen, Germany, [2]School of Resources and Environmental Engineering, Hefei University of Technology, Hefei, Anhui, China, [3]Department of Natural Sciences, Faculty of Science and Engineering, Tokyo City University, Tokyo, Japan

The histology of bone can be preserved virtually unaltered for hundreds of millions of years in fossils from all environments and all vertebrate taxa, giving rise to the flourishing field of paleohistology. The shafts of long bones are formed by the apposition of periosteal bone tissue, similar to the growth of wood, and preserve an often cyclical record of the growth in the individual and events in its life history. One such event is sexual maturation or puberty, during which hormonal changes transform the juvenile into a sexually mature adult. Puberty has been well studied in humans and some other living vertebrates. Here we describe puberty in *Keichousaurus*, a small sexually dimorphic and live-bearing marine reptile from Middle Triassic rocks of SW China, about 240 million years old. Using a combination of bone histology and morphology, we detected puberty as one of four life stages (the others being fetus, juvenile, and adult). Adult *Keichousaurus* males have a more robust humerus than females with pronounced muscle attachment sites and a triangular shaft cross section. Mid-shaft sections of the humeri of the males show the transition from the rounded juvenile cross section to the triangular adult cross section, as reflected in the contour of the growth marks. This shape change is produced by differential bone apposition of the periosteum, presumably triggered by sex hormones, as in humans, and influenced by changes in loading regime during puberty. This is the first report of puberty in a fossil amniote.

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Paleontological Management Poster Session (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**A NEW TYPE OF RAPTOR: RECREATION AND PERMIT TRACKING ONLINE REPORTING**

Liggett, Gregory A.

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The Bureau of Land Management (BLM) has developed a new online platform for applications and reports for several BLM programs. RAPTOR (Recreation And Permit Tracking Online Reporting) includes Paleontological Resource Use Permits, Special Recreation Permits (SRP), and General Science permits. The motivations for creating the system include establishing a digital system of record for these federal records; making internal and external communication easier; increasing transparency; providing consistency across the bureau; providing tracking and automation features; and offering flexibility. Currently, the Paleontology module of RAPTOR is being used primarily in the BLM's Montana/Dakotas State Office, where we are responding to feedback from both internal and external users. This pilot of the system has proven to be very valuable for identifying bugs and system enhancements that will result in a better user experience. External paleontology users create an account to access RAPTOR. Requirements include uploading a resume or CV and uploading a repository (museum) agreement indicating the repository is aware of the work and agrees to curate the material collected. The system allows long narratives to address basics about the proposed work and allows an applicant to attach additional documentation, including photographs, publications, and Google Earth files to help BLM evaluate the proposal. The system will route the applications to the appropriate reviewing office, and internal users are notified that an application is awaiting review. Internal review consists of making sure the applicant(s) are minimally qualified to conduct the work; reviewing the proposed work; satisfying the mandates of the National Environmental Policy Act (NEPA) of 1970; and applying appropriate terms and conditions. Once a permit is issued, the external user gets three reporting tasks: the Report, the Repository Receipt, and the Locality Report. A tremendous benefit of the paleontology module of the RAPTOR system is that BLM created a corporate data schema for our locality data. Several templates were developed that users enter locality data into, and then upload those completed files. After review the uploaded locality data goes into the corporate locality data without needing an additional manipulation.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**SASKATCHEWAN EUSUCHIAN CENSUS: NEW CRETACEOUS AND PALEOGENE CROCODYLIFORM SPECIMENS FROM THE CANADIAN PRAIRIES**

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Crocodyliform fossils representing extinct close relatives and members of modern families are common finds in southern Saskatchewan, Canada, spanning a largely continuous interval of the Upper Cretaceous and Paleogene. Although these specimens are recovered from units coeval with well represented formations to the west (e.g. Middle Campanian Dinosaur Park Formation, Alberta) and south (e.g. Maastrichtian Hell Creek Formation in Montana and North Dakota), only three individuals are well documented in literature. We present several newly discovered and undescribed specimens providing taxonomic resolution of crocodyliforms from the Campanian to late Eocene in Canada. Two specimens with cranial material from the latest Maastrichtian Frenchman Formation are referrable to *Borealosuchus* and *Brachychampsa*, the most common crocodyliform taxa represented in this region at this time. A massive caniniform tooth from the East Block of Grasslands National Park bears a striking resemblance to those of the gavialoid-like thoracosaurs and may be the first evidence of these animals in Canada. Additional specimens from the Paleocene Ravenscrag Formation are referable to *Borealosuchus*. Specifically, osteoderms from the upper buff facies outcrops in the Souris River Valley (Tiffanian NALMA) resemble that of *Borealosuchus*, possibly belonging to a late Paleocene taxon such as *B. formidibilis*. Crocodyliforms are among the rarest vertebrate groups represented from lower Cypress Hills Formation (Chadronian NALMA). It is currently not possible to precisely diagnose these materials, though fragmentary cranial material suggests they belong to Alligatoroidea, consistent with complete skeletons of *Alligator prenasalis* known from South Dakota and Nebraska. This material represents the northernmost known biogeographical extent of many well-known taxa, demonstrating the importance of Saskatchewan localities in the study of crocodyliforms from the Great Plains.

**Funding Sources** This research is supported by the George J. McLeod Research Enhancement Chair Fund in Geology.

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Technical Session 13: Fishes - Actinopterygians (Friday, October 20, 2023, 1:45 PM)

**SENSE AND SENSIBILITY: ESTIMATING AND COMPARING THE HEARING CAPABILITY OF OTOPHYSAN FISH USING DYNAMIC FINITE ELEMENT METHODS**

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Sensory biology is an area of vertebrate paleontology that has remained relatively inaccessible because of the rarity of preservation. Recent advances in imaging and computational modeling permit a renewed research program focusing on the structure and function of sensory systems. Here we introduce a new framework for studying the auditory systems in vertebrates using dynamic finite element analysis (dFEA). We use otophysan fish as a model system and constructed dFE models to estimate their hearing capability and characteristics, as their Weberian ossicles are functional analogues of the middle ear ossicles of tetrapods. We scanned taxa from the orders Cypriniformes (carp-like fish) and Siluriformes (catfish) using high-resolution X-ray computed tomography (CT). 3D Weberian ossicle models were segmented out from CT images and converted into CAD meshes for simulation. Using the 3D meshes as well as known anatomical boundaries and conditions of the Weberian apparatus, we then built dFE models of zebrafish (*Danio rerio*) and bullhead catfish (*Ameiurus nebulosus*) as representatives of above orders respectively. We conducted harmonic analyses to evaluate how ossicle chains in different species respond to a range of auditory frequencies. The simulated auditory responses were validated by published experimental data on audiograms of the model species. Both zebrafish and bullhead catfish dFE models show a most sensitive frequency around 1 KHz despite different morphology of the ossicles. However, the sound conduction efficiency of the ossicular chain is much higher in catfish than that in zebrafish. This functional difference is grounded in morphological differences; whereas the elongated and pointed tip of the tripus in zebrafish is attached to the dorsal slit edge of the tunica externa of the gas bladder, that of bullhead catfish is inserted in the tunica externa medially with extensive contact with the tunica. These connections are further facilitated by distinctive tripus shapes (triangular vs. tilted hook-shape). Lastly, resonance frequency negatively covaries with ossicle size but appears to be isometric after size correction. These findings suggest that dFEA has potential to permit improved estimation and reconstruction of the hearing capability of extinct fish taxa. This approach forms a basis for future applications to the analysis of hearing ossicles in other vertebrates in non-aquatic habitats such as terrestrial, subterranean, and aerial environments.

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Technical Session 6: Marine Reptiles (Wednesday, October 18, 2023, 1:45 PM)

**AN ARMORED MARINE REPTILE FROM THE EARLY TRIASSIC OF SOUTH CHINA WITH IMPLICATIONS FOR THE PHYLOGENY OF ARCHELOSAURIA**

Liu, Jun, WOLNIEWICZ, ANDRZEJ S., Li, Qiang, Qiao, Yu, Hu, Yi-Wei

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Sauropterygia was a taxonomically and ecomorphologically diverse clade of Mesozoic marine reptiles spanning the Early Triassic to the Late Cretaceous. Sauropterygians are traditionally divided into two groups representing two markedly different body plans – the short-necked, durophagous Placodontia and the long-necked Eosauropterygia – whereas Saurosphargidae, a small clade of armored marine reptiles, is considered as the sauropterygian sister-group. However, the early evolutionary history

of sauropterygians and their phylogenetic relationships with other groups within Diapsida are still incompletely understood. Here, we report a new saurosphargid from the Early Triassic of South China, representing the earliest known occurrence of the clade. An updated phylogenetic analysis focusing on the interrelationships within diapsid reptiles recovers saurosphargids as nested within sauropterygians, forming a clade with eosauropterygians to the exclusion of placodonts. Furthermore, a clade comprising *Eusaurosphargis* and *Palatodonta* is recovered as the sauropterygian sister-group. The phylogenetic position of several Early and Middle Triassic sauropterygians of previously uncertain phylogenetic affinity, such as *Atopodentatus*, *Hanosaurus*, *Majiashanosaurus* and *Corosaurus*, is also clarified, elucidating the early evolutionary assembly of the sauropterygian body plan. Finally, our phylogenetic analysis recovers Testudinata and Archosauromorpha within Archelosauria, a result strongly supported by molecular data, but until now rarely recovered by any phylogenetic analysis using a morphology-only data set. Our study provides evidence for the rapid diversification of sauropterygians in the aftermath of the Permo-Triassic mass extinction event and emphasizes the importance of broad taxonomic sampling in reconstructing phylogenetic relationships among extinct taxa.

**Funding Sources** This work was supported by the National Natural Science Foundation of China (grant numbers 42172026, 41772003, 42202006 and 41902104).

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Technical Session 3: Fishes & Amphibians (Wednesday, October 18, 2023, 8:00 AM)

## THE STEM OSTEICHTHYAN *ACHOANIA* FROM CHINA SHEDS LIGHT ON THE COMPLEX PATTERN OF PARASPHENOID IN CROWN GNATHOSTOMES

Liu, Xiaoyue, Zhu, Min, Lu, Jing

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Psarolepids, which are the oldest osteichthyan members found in the Silurian-Early Devonian region of Yunnan, China, have significantly contributed to our understanding of the origin and early evolution of osteichthyans. However, there is still uncertainty regarding the evolutionary changes in the neurocranial structures of psarolepids and their phylogenetic position. In this study, we investigate the braincases of psarolepid *Achoania* and the sphenoid region of other psarolepids (e.g., *Psarolepis* and *Guiyu*) using high-resolution computed tomography (HRCT), which reveals many internal morphological features previously unrecognized among primitive osteichthyans.

The endocast of *Achoania* shares many similarities with placoderms and the stem osteichthyan *Ligulalepis*, such as an oblate nasal capsule and an elongated mesencephalon. It also displays features previously known in crown osteichthyans, such as an elongated olfactory canal and a small angle between the olfactory canals. The most unexpected feature revealed by HRCT is that the parasphenoid in psarolepids (i.e., *Achoania*, *Guiyu*, and *Psarolepis*), previously described as diamond-shaped, is indeed formed by three main parts. The dorsal and lateral portions of the parasphenoid have denticle fields and extend into the ventral floor of the braincase, forming an elongated passage for the buccohypophysial canal. Therefore, psarolepids exhibit the most primitive pattern of the parasphenoid in early osteichthyans, providing further insight into the evolutionary pattern of the parasphenoid in jawed vertebrates.
Our phylogenetic analysis places psarolepids at the stem osteichthyan position, as the sister group to crown osteichthyans (actinopterygians plus sarcopterygians). These new anatomical data on the neurocranium of *Achoania* and the sphenoid region of other psarolepids also improve the neurocranial characteristic sequence of osteichthyans and reveal that the parasphenoid, together with the buccohypophysial canal, underwent dramatic changes at the beginning of osteichthyan evolution.

**Funding Sources** Strategic Priority Research Program of Chinese Academy of Sciences (XDB26000000) and National Science Fund for Excellent Young Scholars (42022011)

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Technical Session 14: Crocodylomorphs & Turtles (Friday, October 20, 2023, 1:45 PM)

## A FRESHWATER PANCHELONIOID TURTLE FROM THE KAIPAROWITS FORMATION (UPPER CRETACEOUS: CAMPANIAN) OF GRAND STAIRCASE-ESCALANTE NATIONAL MONUMENT, UTAH

Lively, Joshua R.[1], Titus, Alan L.[2], Knoll, Katja[2], Suarez, Celina A.[3], Yamamura, Daigo[4], Kirkpatrick, Andrew G.[3]

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Turtles of the clade Panchelonioidea are known from marine and marginal marine settings from the Early Cretaceous to the Recent. Though their relationships and ingroup composition are still debated, the clade is traditionally thought to include Cheloniidae, Dermochelyidae, their respective stem taxa, and Protostegidae. We describe the anatomy and paleoecology of a new protostegid from the fluvial Kaiparowits Formation in southern Utah. The site preserving this taxon also produced tyrannosaurs of various ontogenetic stages, a hadrosaurid, the crocodilian *Deinosuchus*, multiple turtle taxa, fish, invertebrates, and woody debris including charcoal. Thus far, three individuals of varying sizes have been recovered from the site. A fifth or sixth costal over 450 mm in width supports a shell width of well over 1 m for the largest individual.

The Kaiparowits taxon shares a number of features with the putative protostegid *Terlinguachelys fishbecki* from coastal facies of the Aguja Formation in Texas. Both exhibit a long post-dentary mandible relative to dentary length when compared to other panchelonioids, prominent retroarticular processes, a highly ossified plastron and carapace, and similar appendicular morphology. As in other protostegids, the Kaiparowits taxon possesses a coracoid that remains narrow throughout its length and a bowed radius. Preliminary phylogenetic analyses support a sister taxon relationship between the Kaiparowits taxon and *Terlinguachelys* at the base of Protostegidae.

Calcium phosphate from bone of the Kaiparowits taxon and other turtles from the site were analyzed for $\delta^{18}O_P$, $\delta^{18}O_{co3}$, and $\delta^{13}C_{co3}$ to determine habitat usage by the respective taxa. Though slightly more enriched than other turtles at $\delta^{18}O_P = 12.3 \pm 1.3‰$ VSMOW, those data, a $\delta^{13}C_{co3} = -7.13 \pm 1.09‰$ VPDB, and a $\delta^{18}O_{co3} = -10.99 \pm 0.44‰$ VPDB indicate the Kaiparowits taxon exhibits a freshwater isotopic signature. This contrasts with previous studies of the isotopic composition of marine protostegids from the Western Interior Seaway, which show a $\delta^{18}O_p$ range of 16.18 – 20.53‰. It also differs from modern marine herbivorous turtles, whose $\delta^{13}C_{co3}$ average +0.4‰, suggesting the Kaiparowits taxon may have been carnivorous. An obligate freshwater ecology for the Kaiparowits taxon is a novelty within the ≥120 Ma fossil record of panchelonioids. At over one meter in width, the Kaiparowits taxon was likely the largest freshwater turtle in the Cretaceous, if not the entire Mesozoic.

**Funding Sources** US Bureau of Land Management; Prehistoric Museum, Utah State University Eastern; University of Arkansas at Fayetteville

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Technical Session 3: Fishes & Amphibians (Wednesday, October 18, 2023, 8:00 AM)

## NEW ANATOMICAL INFORMATION ON THE PLACODERM FISH *GROENLANDASPIS*

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The Middle-Late Devonian arthrodire *Groenlandaspis* (Arthrodira, Groenlandaspididae) is known from Greenland, Europe, USA, Turkey, South Africa, Australia and Antarctica, but only a few species have been formally described. It is a significant genus for use in biostratigraphic correlations as it restricted to the late Famennian stage in Europe, South Africa and the USA, but occurs in much older Middle Devonian sites in East Gondwana. It is represented mostly from isolated dermal plates and a few articulated specimens of the dermal shields.
New complete, well-preserved specimens of a new species of *Groenlandaspis* from the Middle Devonian (Givetian) lagerstätte at Mt. Howiitt reveal the jaws and dentition, parasphenoid and entire body shape of this placoderm for the first time. The undeveloped infragnathals are a basal feature for arthrodires, but it is specialized in having just one median anterior supragnathal, and by the elongated shape of the posterior supragnathals. Rounded, flat scales cover the body which bear fine tubercular ornamentation.

The late Famennian Canowindra site in New South Wales has also produced a number of well-preserved, complete 3D articulated dermal armor of a new species of *Groenlandaspis*, but details of internal anatomical features are lacking. Collectively, these new specimens provide much information about the variability of key diagnostic bones used in identification, like the Median Dorsal and Posterior Dorsolateral plates. A new phylogenetic analysis of all known *Groenlandaspis* species shows the basal position of East Gondwana forms and relationships to older Early Devonian arthrodire taxa. It supports the migration of the genus from East Gondwana into Euramerica in Late Devonian, following a similar biogeographic pattern of *Bothriolepis* and phyllolepids.

**Funding Sources** Australian Research Council DP200103398

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

### RAPID SCREENING OF TAR SEEP FOSSILS FOR RADIOCARBON AND STABLE ISOTOPE ANALYSIS

Lopes, Lauren E.[1], Holroyd, Patricia A.[2], Ro, Hyejoo[1], Southon, John[3], Kim, Sora[1], Trayler, Robin[1]

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Tar seeps trap and preserve diverse fossil assemblages which reflect unique environmental histories and ecosystem interactions. While the macro preservation of the fossils is usually good, preservation of organic bone collagen is often variable. Radiocarbon dating ($^{14}C$) and stable isotope analysis ($\delta^{13}C$, $\delta^{15}N$) of tar seep taxa are complicated by tar infiltration. The removal of exogenous tar, which has a high carbon content, is complex and time-consuming. Identifying which bones preserve collagen in a rapid and cost-effective way with minimal damage *prior to* further sampling and tar removal methods would save significant resources and minimize damage to collections.

We used both visual inspection for weathering and tar infiltration and minimal (2-5 mg) sampling of bone for infrared spectral analysis to test the suitability of each to detect collagen. We visually scored and collected infrared spectra (FTIR) from 66 samples from the Rancho La Brea and McKittrick tar seep collection housed in the University of California Museum of Paleontology (UCMP) which have previously been successfully or unsuccessfully radiocarbon dated. We also collected data for ~80 McKittrick tar seeps fossils with unknown collagen preservation. FTIR spectra of cortical bone samples exhibited prominent and quantifiable absorbance bands for organic amide, phosphate, and carbonate groups. We calculated three indices from the absorbance bands to examine collagen preservation, bone crystallinity, and tar content. Our results from the previously investigated fossils show that FTIR can distinguish tar seep fossils with well-preserved collagen from poorly preserved specimens. Approximately half of the unknown McKittrick tar seep data fell within the “well preserved” group indicating sufficient collagen preservation. Although we found collagen is less often found in more weathered fossils, visual cues alone were not a reliable indicator. This preliminary, rapid, and minimally destructive assessment can identify samples suitable for radiocarbon dating and stable isotope analyses, which can increase the success rate of these more costly and time-consuming analyses.

**Funding Sources** NSF-EAR-2138163

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

### THE SHAPE OF SPEED: THE RELATIONSHIP BETWEEN 3D HUMERUS SHAPE AND MAXIMUM RUNNING SPEED

Lopezalles, Sierra

Biology, Indiana University, Plainfield, Illinois, United States

Estimates of running speed are useful for many kinds of paleontological reconstructions, including the co-evolution of predators and prey and inferring the hunting strategies of extinct species, however previous studies have failed to find a significant relationship between skeletal morphology and speed. This study capitalizes on the high degree of variation in morphology and functional ability across domestic dog breeds to investigate whether shape data can be used for estimating running speed effectively. Here I utilize three-dimensional landmark-based geometric morphometrics and the exceptional historical records from competitive dog races to assess the relationship between humerus shape and relative maximum running speed across dog breeds. Selective breeding of dogs has pushed the morphological variation in dog breeds to the extremes, creating dog breeds with a variety of humeral shapes and a wide range of maximum running speeds from the Basset Hound and Shih Tzu at 34 km/h to the Whippet and Grey Hound at 65 km/h. For each breed, maximum running speed was determined using records from the American Kennel Club's (AKC) Fast Coursing Agility Test, which is a timed 100-yard sprint. Speeds were normalized by calculating their Froude number and then regressed onto shoulder height in order to obtain an accurate metric of breeds that are fast for their size. Results indicate that there is a strong and significant relationship between the maximum relative speed of the breed and shape of the humerus driven by a combination of the shape of the distal articulation and bone robustness ($R^2 = .53$, $p < .001$). Overall, breeds that are fast for their size have generally more slender humeri with less curvature in the shaft. Additionally, tests of this dog-based predictive equation on wild canids supports a future application of this method to the estimation of locomotor performance in fossil canids.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**BRAIN SIZE ALLOMETRY AND ENCEPHALIZATION QUOTIENTS IN EUARCHONTOGLIRES**

López-Torres, Sergi[1], Bertrand, Ornella C.[2], Fostowicz-Frelik, Lucja[3], Lang, Madlen[4], Law, Chris J.[5], San Martin Flores, Gabriela[4], Schillaci, Michael[4], Silcox, Mary T.[4]

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The timing and nature of evolutionary shifts in the relative brain size of Primates has been extensively studied. As an element of this, the order has historically received much attention regarding how their brain size scales relative to body size. However, the broader phylogenetic context of this relationship has been less extensively studied; this context is fundamental for understanding those shifts. Equations describing these scaling relationships are also employed in calculation of Encephalization Quotients (EQ) for comparisons of relative brain size, which are essential for interpreting data from fossils. The current study allows for the development of metrics that are more targeted than existing equations based on general mammalian samples to particular questions in euarchontogliran brain evolution.

Ordinary (OLS) and phylogenetic generalized least squares (PGLS) regressions were fitted to the largest euarchontogliran dataset of brain and body size, comprising 715 species of Primates, Scandentia, Dermoptera, Lagomorpha, and Rodentia. Contrary to previous inferences the lagomorph brain (PGLS = 0.465; OLS = 0.593) scales relative to body mass similarly to rodents (PGLS = 0.526; OLS = 0.638), and differently than primates (PGLS = 0.607; OLS = 0.794). There is a shift in the pattern of the scaling of the brain in Primates, with Strepsirrhini occupying an intermediate stage, being more similar to Scandentia but different from Rodentia and Lagomorpha. The unique brain-body scaling relationship of Primates among Euarchontoglires illustrates the need for clade-specific EQs for more restricted taxonomic entities than Mammalia. We created clade-specific regular and phylogenetically-accounted EQ equations at superordinal, ordinal, and subordinal levels. When using fossils as test cases, our results show that generalized mammalian equations underestimate the encephalization of the stem lagomorph *Megalagus turgidus* in the context of lagomorphs but overestimate the encephalization of the stem primate *Microsyops annectens* and the early euprimate *Necrolemur antiquus* in the context of primates. In contrast, generalized mammalian equations provide similar EQ values to our new strepsirrhine-specific EQ when applied to the early euprimate *Adapis parisiensis*. These results highlight the importance of understanding patterns of brain-body scaling in interpreting fossils in an evolutionary context.

**Funding Sources** NCN 2022/45/NZ8/03585 (SLT); H2020-MSCA-IF-2018-2020 792611 (OCB); NSERC CGS (MML); Gerstner FF & UT Provost F. (CJL) & NSERC DG (MTS).

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Paleontological Management Poster Session (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**WHAT'S IN A NAME? PUTTING DECOLONIZATION OF SCIENTIFIC NOMENCLATURE INTO PRACTICE THROUGH LOCAL COMMUNITY PARTNERSHIPS**

Lovelace, David M.[1], LeClair-Diaz, Amanda[2], Kufner, Aaron M.[3], So, Calvin[4], Fitch, Adam[5], Woznkick, Hawke[6], Parrish, Ethan[3], Acosta, Matilde R.[7]

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In order to effectively communicate, humans create representative names and classifications for our surroundings. Objectively, what an object is called does not inherently change the object. However, names clearly have power and meaning in and of themselves and those names both translate to and impact how something is perceived. The effects of colonization are multidimensional and have a lasting impact on languages and culture that spans generations. Geographic landmarks, rivers, and flora and fauna are commonly renamed by colonizers, largely as a means of capitalizing ‘resources’ (including extracting fossils). Historically, this has been done with little to no consideration of local names or the involvement of local peoples or communities who understand the context and cultural significance of the biotic and abiotic landscape. Those ‘new’ names are then perpetuated throughout the Western science lexicon leading to nomenclature laden with an overprint of colonial practice and tradition (including the use of eponyms). There have certainly been efforts to be more inclusive and these run the spectrum from unintentional appropriation to being culturally inclusive. As practitioners of largely field-based sciences (i.e., geology and biology), we have an opportunity to move beyond historical practices towards a more formalized decolonization of scientific nomenclature. Although any relationship built with local communities where fieldwork is done will likely follow different paths and have varying results, the principles of the four R’s (Respect, Relevance, Reciprocity, and Responsibility) are fundamental. Over the last decade, our team has discovered several new taxa in the Upper Triassic Popo Agie Formation of west-central Wyoming, USA on lands under the jurisdiction of federal and state agencies. In the wake of the COVID-19 pandemic and the more broadly recognized need for social justice and representation, what initially started out as a Land Acknowledgement has been cultivated into a meaningful partnership with First Nations tribes of the Wind River Reservation. The naming of these new taxa (i.e., *Beesiiiwo cooowuse*) has incorporated a multigenerational approach that includes Tribal students and educators, Elders, and government officials, many of whom are co-authors on the descriptive papers. Through this partnership we have learned new ways to improve fieldwork, integrating Western and Native science in a way that respects and honors the local community.

**Funding Sources** UW-Madison Brittingham Fund; Friends of the Geology Museum; Sherry Lesar Fund for Geological Wonder

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Romer Prize Session (Thursday, October 19, 2023, 8:00 AM)

## THE EVOLUTION OF STERNUM-DRIVEN POWERED FLIGHT IN PENNARAPTORA

Lowi-Merri, Talia

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A large sternum with a prominent keel has long been regarded as a key indicator of powered flight in both crown birds (Neornithes) and fossils along the avian stem lineage. Sternum morphology is highly variable in Neornithes and shows associations with some locomotor styles, which provides the opportunity to test hypotheses about stem bird flight abilities and sternum-driven flight origins. I address the following questions: 1) Which pennaraptorans have a large enough sternum to facilitate flight comparable to that of Neornithes, and 2) how do key features of the sternum, including relative size, dimensions, and an enlarged keel co-evolve through evolutionary time? Here, I performed multivariate phylogenetic regression model comparisons and ancestral character estimations to analyze relationships between sternum size relative to body mass, flight capabilities, and other sternal modifications, and examine the sequence of sternal trait acquisition across 112 neornithine and 25 Mesozoic pennaraptoran taxa. Phylogenetic comparative analyses reveal that in Neornithes, flightless birds have relatively smaller sterna than fliers, with equally small sizes found in oviraptorosaurs and most dromaeosaurs. A marked increase in size occurs in Avialae at *Jeholornis*, with a sternum size comparable to continuous flapping

birds. This size increase at Avialae coincides with sternal elongation and directly precedes the appearance of a low midline ridge for a keel at Pygostylia. Ancestral state estimations show that sternum size increases again in crownward Ornithuromorpha, reconstructed at the ancestor of *Gansus* and Songlingornithidae; this relative increase in sternum size is correlated with the evolution of a fully developed keel and enlarged caudolateral trabeculae, both crucial areas of flight muscle attachment. Interestingly, sternal dimensions strongly suggest that burst flight, a flight style associated with poor flying birds and previously inferred to have been present in early Avialae, is a derived flight style within Neornithes and was not ancestral or transitional in the evolution of powered flight. These results indicate that early beginnings of sternum-driven flight likely occur in basal Avialae with *Jeholornis*; however, advanced sternum-driven powered flight is prevalent only within Ornithuromorpha. These novel insights into the sequence of flight evolution in Pennaraptora emphasize the importance of sternum morphology in understanding fossil bird locomotion.

**Funding Sources** This work was funded by a NSERC Doctoral Postgraduate Scholarship (PGSD3-547147-2020).

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Technical Session 8: Mammal Paleoecology (Thursday, October 19, 2023, 1:45 PM)

### EARLY MIOCENE EVIDENCE FOR ABUNDANT $C_4$ VEGETATION AND HABITAT HETEROGENEITY IN EASTERN AFRICA

Lukens, William[1], Fox, David L.[2], Deino, Alan L.[3], Kinyanjui, Rahab[4], Michel, Lauren[5], Novello, Alice[6], Peppe, Daniel J.[7], Strömberg, Caroline A.[8], Uno, Kevin[9], Kingston, John D.[10]

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The Late Miocene emergence and proliferation of $C_4$ grasses across eastern Africa is central to current evolutionary interpretations of many mammal lineages, including our hominin ancestors. This model of $C_4$ expansion is supported by densely sampled late Neogene to Quaternary localities, yet a relative paucity of data from Early to Middle Miocene sites has inhibited a full understanding of the origins of $C_4$ grasses in eastern Africa. This study reports the results of a decade-long investigation into nine Early Miocene mammal site complexes across Kenya and Uganda. Our multi-proxy approach combined analyses of plant silica microfossils (phytoliths) with stable carbon isotopic data from soil organic matter, plant waxes, and pedogenic carbonates to document vegetation structure within a robust geochronologic and sedimentologic framework. The results demonstrate clear, multi-proxy evidence for locally abundant $C_4$ grasses at multiple sites between 21 and 16 Ma. Variability in proxy signals both within and between sites suggests that habitat heterogeneity was a common feature across multiple spatial and temporal scales. We applied a Monte Carlo approach to quantify $C_4$ grass abundance using the stable carbon isotope data and demonstrate with >95% confidence that $C_4$ plants have been present since the earliest Miocene (~21 Ma). This finding conflicts with decades of prior work from paleosols and paleodiets but supports molecular clock studies of $C_4$ origins, new phytolith records, and Neogene paleo-$CO_2$ reconstructions. These results should inspire a reanalysis of deep-time dietary reconstructions from fauna in the region, including our hominoid ancestors and their associated faunal communities.

**Funding Sources** National Science Foundation, Leakey Foundation

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Education & Outreach Poster Session (Saturday, October 21, 2023, 4:30 - 6:30 PM)

### DIFFERENTIATED OUTREACH STRATEGIES FOR RURAL AND URBAN ENVIRONMENTS TO PROMOTE LEARNING, EQUITY, AND INCLUSION

Lukowski, Stephanie M.[1], Smith, Kathlyn M.[2]

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Community engagement though outreach, defined here as programs and events that do not occur at the host's physical location, is an important part of museum educational programming. Many museums use outreach as an opportunity to interact with populations that might not otherwise visit the museum for a variety of reasons that may include lack of transportation, financial ability, or even awareness that the museum exists or contains content relevant to an individual's interests. The Georgia Southern Museum is located on the Statesboro, Georgia campus of Georgia Southern University. As the only museum in Georgia with a natural history collection within an approximate 100 mi/160 km radius, the Georgia Southern Museum is uniquely situated to serve the city center that is the Statesboro campus, its surrounding rural communities, the students on the University's Armstrong Campus (Savannah, GA), and the broader community within Savannah including suburban communities and tourists. As such, museum staff has adopted a variety of strategies to provide place-based, hands-on educational experiences utilizing fossils, adapted to diverse audiences and settings.

Developing community partnerships in both rural and urban settings has proven key to reaching a wide audience within the region. In Savannah, we have worked with local businesses such as Neighborhood Comics and organizations that include Savannah ComicCon and the Girl Scouts. In neighboring Tybee Island, we have also partnered with the Tybee Island Marine Science Center to host pop-up museums that have boosted their attendance and raised awareness of the existence of our museum as well as the fossil resources in the region. Meanwhile, in rural settings, we have found it valuable to partner with local governments and school districts to bring materials to community events and festivals as well as directly to schools.

Perhaps the biggest challenge faced by the museum is engaging college students on the University's two campuses. By hosting pop-up museums at various high traffic locations throughout the year on both campuses, we have had success in raising awareness of the museum among the student body. Along with increased awareness, the Museum has also seen an increased pool of applicants for student worker positions which has in turn yielded high-quality student workers who assist permanent staff in running these vital programs, thereby increasing the quality of delivery and quantity of programs.

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Preparators' Session (Thursday, October 19, 2023, 8:00 AM)

**WORKING WITH GIANTS: LOGISTICS AND SAFETY OF MOVING, ROTATING, AND PREPARING OVERSIZED, MULTI-TON FOSSIL BLOCKS**

Lund, Eric, Herzog, Lisa, Anné, Jennifer, Knowles, Aubrey, Zanno, Lindsay E.

Paleontology, North Carolina Museum of Natural Sciences, Raleigh, North Carolina, United States

Preparation and conservation of oversized fossil blocks (>1,000 kg) creates countless logistical, safety, and ergonomic challenges, and concerns for preparators, facilities infrastructure, and the specimens themselves. These challenges and concerns include, but are not limited to, preservation quality and stability of the fossils, infrastructure limitations (e.g., weight bearing capacities of floors), transport challenges of lifting, rotating, and moving massive fossil blocks, safety concerns for staff, visitors, and the fossils, and ergonomic concerns for preparation staff. To ameliorate many of these challenges and concerns, the North Carolina Museum of Natural Sciences (NCMNS) paleontology unit embarked on an ambitious project to design and build a world-class public fossil preparation space uniquely equipped and capable of safely and effectively moving, lifting, rotating, preparing, and exhibiting massive fossil specimens utilizing three dimensional space. The project started with increasing the overall floor capacity of the new lab from 9 lbs. per square foot to 400 lbs. per square foot to accommodate the combined weight of multi-ton blocks and the equipment needed to hold and manipulate them. In consideration of safely lifting these oversized blocks, NCMNS installed a 10-ton overhead bridge crane capable of smoothly hoisting and transporting blocks almost anywhere within the lab space. Additionally, proper preparation and conservation will require the massive fossil blocks to be tilted and rotated in small increments to access sides and bottoms. To accomplish this delicate maneuvering, paleontology staff worked with engineers to custom design and commission a modular incremental fossil rotator

frame (a dinosaur "rotisserie") which allows blocks of various sizes, up to 6-tons, to be relatively easily and safely tilted, rotated, or flipped. The rotisserie facilitates preparation by changing the relative position of fossil blocks and working surfaces into more ergonomic and easily accessible positions, all while maintaining a safe and stable working environment. Considered together, the features of the newly constructed public preparation space improve the safety, ergonomics, and feasibility of preparation and conservation of multi-ton fossil blocks.
**Funding Sources** NC State Employees Credit Union, Wake County, State of North Carolina, NCMNS Friends of the Museum

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Education & Outreach Poster Session (Saturday, October 21, 2023, 4:30 - 6:30 PM)

### STUDENT ENGAGEMENT THROUGH COLLABORATIVE FIELD ANATOMICAL AND TAXONOMIC GUIDES

Lundeen, Ingrid K.[1], Melstrom, Keegan M.[2]

[1]Anthropology, Hunter College of the City University of New York, New York, New York, United States, [2]Division of Engineering and Science, Rose State College, Midwest City, Oklahoma, United States
There is often broad interest in paleontology, presenting a gateway into science for students through recruitment of lab and field assistants. In much of paleontology, particularly research that explores whole faunal assemblages, it can take years for students to become proficient in anatomy and taxonomy to feel confident in their role producing knowledge through research. Increasing familiarity with diverse faunas to increase students' confidence should be viewed as a critical step towards ensuring the success of experiential learning opportunities, like field- and lab-based paleontological research. A project was designed to engage students in multiple aspects of paleontological research and increase anatomical and taxonomic fluency. The product was an easy-to-use field ID guide to give students increased confidence and the ability to take a more active role in initial faunal IDs. This project was carried out over the course of twelve months where undergraduates at the University of Texas at Austin (n=12) built a site-specific middle Eocene (Bridgerian) field guide (BFG). Students used historic and modern primary literature to assemble lists of potential fauna, providing anatomical context through clade-specific anatomical diagrams. For each clade, major anatomical features were outlined, and potentially present taxa were listed, briefly defined by significant anatomy, and, where available, figured. References were managed in a Mendeley project, including a database of PDFs of all primary literature. Students worked together to design and assemble contextual resources within the BFG including a scale bar on the cover, a stratigraphic guide, and a climate summary of the Eocene. Students were then invited to apply the field guide during the 2018 and 2019 field seasons. Following the assembly of the BFG, all students reported feeling more confident in multiple areas including: anatomical IDs, taxonomic IDs, rules surrounding taxonomic nomenclature, engagement with primary literature, acquisition of historical and modern literature, and collaborative project design and workflow. Additionally, multiple students used the skills developed while building the BFG as foundations for further research in related topics. Undergraduate student taxonomic and anatomical fluency was substantially increased by the assembly of this collaborative field guide, enabling field and lab assistants to feel more confident in their ability to substantively participate in research.

**Funding Sources** Evolving Earth Foundation; Geological Society of America; Paleontological Society

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

### ADDITION, LOSS, AND EXPANSION OF OLFACTORY TURBINALS AMONG EXTINCT AND EXTANT PRIMATOMORPHANS

Lundeen, Ingrid K.

Anthropology, Hunter College of the City University of New York, New York, New York, United States

Among extant mammals, there is considerable variation in olfactory turbinals, the thin scrolls of olfactory epithelium-lined bone found in the nasal cavity. These turbinals include ethmoturbinals, frontoturbinals, and nasoturbinals, all named for the cranial element from which they arise. Next to cetaceans, haplorhine primates are characterized by one of the most dramatic reductions in turbinal numbers seen across mammals. Recent work has demonstrated that there is also considerable variation within the primate order. In the haplorhine clade, there is a substantial loss in both the number and complexity of olfactory turbinals although some taxa within this lineage (e.g. *Aotus*) have evolved an increased olfactory turbinal complexity. In other clades, like among extant strepsirrhines, there is considerable morphology variability in turbinal size, complexity, and count. While olfactory turbinals have now been extracted from cranial CT data from Eocene omomyids (*Rooneyia* and *Shoshonius*) and a Miocene fossil anthropoid (*Homunculus*), the condition seen in adapiform primates is uncertain, thus the primitive condition in primates remains unclear. Here, I present the turbinal anatomy of four genera of Eocene adapiform primates representing the European adapid clade (*Leptadapis* and *Adapis*) and the North American notharctid clade (*Notharctus* and *Smilodectes*). Turbinal anatomy of these specimens, particularly the well-preserved *Leptadapis leenhardti* (YPM-011481), reveals four ethmoturbinals and two frontoturbinals. This finding suggests that the condition seen among multiple extant strepsirrhines characterized by five ethmoturbinals and up to four frontoturbinals is derived within these clades and the adapiform turbinal number is retained from the primitive primate condition. This predicted ancestral condition is bolstered by data from extant tree shrews and both extant and fossil rodents, which all have turbinal numbers similar to those seen in the adapiformes examined here. These findings suggest an independent evolution of an expansive fifth ethmoturbinal in dermopterans and calls for increased study of the nasal cavity of other fossil primatomorphans.

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Technical Session 18: Synapsids (Saturday, October 21, 2023, 8:00 AM)

**QUALITATIVE AND QUANTITATIVE DATA COMBINATIONS REVEAL UNIQUE PATTERNS IN THE POST-CRANIAL ANATOMY AND TAXONOMY OF SPHENACODONTIDAE (SYNAPSIDA: SPHENACODONTIDAE)**

Lungmus, Jacqueline K.

OU Geosciences, Sam Noble Museum of Natural History, Norman, Oklahoma, United States

The sail-backed *Dimetrodon* is one of the most iconic members of the Paleozoic fauna of the American west. 2D geometric morphometric analysis was conducted on a sample of sphenacodontid humeri and femora to quantify the shape variation and range of specimens with known identifications. These morphological data were associated with a range of categorical data, such as locality and geologic context. This dataset subsequently underwent a Gower dissimilarity analysis to create a corrected distance matrix and a secondary Principal coordinates analysis. This creates a new “trait” matrix representing a combination of the morphometric PC scores and the classification data. As such, the analysis considers how the quantitative shape data is correlated with the qualitative data in determining specimen placement in tangent space.

Because of the outdated species-level taxonomy of sphenacodontids, work on macroevolutionary trends, biogeography, community structure, and morphological disparity of the group is difficult, despite the existence of large collections in many major natural history museums. Considering this, the goal was to create a framework using a combination of specimens, size and stratigraphic occurrences that can all contribute to the species level taxonomic designations. Clarification surrounding species identification in this group advances the use sphenacodontid collections all across the country, heretofore an under-utilized paleontological resource.

This analysis provides insights into areas of *Dimetrodon* taxonomy that are deserving of reassessment and point to examples of biases in collecting and taxonomic assignment by pinpointing redundancies in the morphology and paleobiogeography of these animals. This work suggests features like size and location play an outsized role in the group’s taxonomy, hindering work on macroevolutionary trends despite the existence of large collections in many major American natural history museums.

**Funding Sources** Smithsonian National Museum of Natural History Peter Buck Deep Time Fellowship

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**REANALYSIS OF A PENNSYLVANIAN VERTEBRATE ASSEMBLAGE FROM THE EASTERN UNITED STATES PROVIDES INSIGHTS INTO DIVERSITY AND PALEOBIOGEOGRAPHY**

Lyons-Weiler, Zachary J.

Biological Sciences, University of Pittsburgh, Pittsburgh, Pennsylvania, United States

The Pennsylvanian and early Permian deposits of Pennsylvania, Ohio, and West Virginia have yielded fossil vertebrates for over a century, but the actinopterygian members of this fauna remain neglected. Recent study of Carboniferous–Permian actinopterygians provides crucial insight into the origin and evolution of what is today the most speciose vertebrate clade. We made new collections from the Birmingham Shale (Kasimovian), which represents the final transgression of an inland sea. The base of this unit is a lacustrine, carbonaceous shale bearing disarticulated actinopterygian and chondrichthyan remains along with rare sarcopterygian fishes and tetrapods. Relevant material was mechanically prepared using air abrasion, with select specimens examined using micro-computed tomography. Our material includes a range of actinopterygians. We confirmed the presence of the round scaled *Sphaerolepis* and recorded the predatory *Progyrolepis* for the first time. Additional actinopterygians are represented by braincases and partially articulated body fossils that indicate greater taxonomic diversity than previously reported. This increases the number of known actinopterygian taxa from two to five. Taxonomic similarities between localities bearing Carboniferous-Permian transition aged vertebrates suggest some level of biologic connection across Euramerica. Both *Progyrolepis* and *Sphaerolepis* support this pattern, occurring across North America and Europe from the Kasimovian to the Asselian. To assess faunal similarity, we assembled a list of almost 100 genera spanning the Moscovian-Gzhelian interval from over 20 fossil sites in the Appalachian and central European basins derived from coal swamp, lacustrine, and fluvial deposits. Alroy-Forbes distances, NMDS and Principal Coordinates Analyses were conducted indicating a weak relationship between central European and Appalachian Basin localities, though certain sites dominated by actinopterygians cluster together, while localities dominated by tetrapods exhibit greater levels of endemism. Our understanding of ecological dynamics during this window of time is crucial, as the Pennsylvanian-Permian transition bore witness to significant climatic shifts as well as the origination and diversification of many of today’s dominant vertebrate clades. Further analyses and more rigorous fieldwork are needed to determine whether these relationships are resultant from true signals or are the result of collections bias and other errors.

**Funding Sources** University of Michigan College of Literature, Science, and the Arts and Department of Earth and Environmental Sciences, NSF EAR 2219007

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

## MASTICATORY BIOMECHANICS IN THE ANKYLOSAURIAN DINOSAUR *PANOPLOSAURUS MIRUS*

Ma, Waisum

National Museum of Natural History, Smithsonian Institution, Kowloon, Hong Kong

Ornithischian dinosaurs, which first appeared in the Late Triassic, included many of the dominant terrestrial herbivores during the Cretaceous. Later-diverging taxa are known for their elaborated skull ornaments, body armor, and specialized feeding apparatus. Dental microwear texture analyses indicate that some ornithischian clades (e.g., Ankylosauria, Ceratopsia, Hadrosauridae) have evolved mastication that involved jaw movement in various directions. Despite the known complexity of ornithischian oral processing, their feeding systems have usually been simplified in existing biomechanical models, considering solely the orthal biting scenario. Here, we used multibody dynamics analysis (MDA) and finite element analysis (FEA) to simulate the masticatory biomechanics of ornithischians. The nodosaurid ankylosaur *Panoplosaurus mirus* from the Upper Cretaceous Dinosaur Park Formation of Alberta (Canada) was used as a case study. We created digital models of the skull of *Panoplosaurus* based on computed tomography (CT) scans and conducted three-dimensional reconstructions of jaw adductor muscles. Muscle forces were calculated and assigned to the MD model for simulating interaction between the cranium and mandible. The resulting bite forces and contact points between upper and lower jaws were recorded for FEA. By constructing sophisticated models using a multifaceted approach, we provide new insights into various aspects of ankylosaurian mastication, such as bite forces, muscle activation patterns, and joint reaction forces. Future studies incorporating more taxa will provide a broader picture of the evolution of mastication in ornithischians.

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Education & Outreach Poster Session (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**FOSSIL SHARK TEETH ACTIVATE ENGAGEMENT AND LEARNING ABOUT AI (ARTIFICIAL INTELLIGENCE) IN FLORIDA PUBLIC MIDDLE SCHOOLS**

MacFadden, Bruce J.[1], Antonenko, Pavlo "Pasha"[2], Perez, Victor[3], Waisome, Jeremy[4], Abramowitz, Brian[2], Killingsworth, Stephanie[1], Parnell, Dennis[4]

[1]Florida Museum of Natural History, University of Florida, Gainesville, Florida, United States, [2]College of Education, University of Florida, Gainesville, Florida, United States, [3]St Mary's College of Maryland, Saint Marys, Maryland, United States, [4]College of Engineering, University of Florida, Gainesville, Florida, United States

In this three-year project, Neogene fossil shark teeth are used as a catalyst to activate learning about AI, specifically machine learning (ML). With a focus on both K-12 teachers and students, this research project and its curriculum will investigate STEM integration, how AI knowledge is being learned, what scaffolding is required, students' and teachers' perceptions and misconceptions, and students' interest and identity in STEM and 21st century careers. During the first year (2022-2023), 12 public middle school (mostly Title 1) STEM educators from Florida formed Cohort 1 and together participated in a week-long summer professional development workshop at the Florida Museum of Natural History under the auspices of the Scientist in Every Florida School Program. Products of that workshop included five lessons that were then implemented by the teachers during the school year, with support from the scientists, the latter including classroom visits.

An integrated set of middle-school learning modules (curriculum), aligned to Florida State Standards (CPALMS; also mapped to NGSS), has been developed to activate engagement and learning about fossil shark teeth, databases, training data sets, ML feature analysis and classification, and bias and misunderstandings about AI and ML. Within the lessons, Google Teachable Machine was deployed to understand the process of ML.

In total, this teacher cohort reached about 300 of their students in 12 public middle schools throughout Florida. This project is being evaluated using IRB-approved e-surveys and focus groups involving the teachers. They initially reported concerns about (1) having access to the technology needed to facilitate AI learning; and (2) teaching the newly learned material for the first time (primarily due to the gap between the summer and when they planned to teach the curriculum during the school year). Our primary findings so far indicate that teachers report new understandings of the integration of paleontology (fossil shark teeth) and AI applications and implementations as well as how these relate to their K-12 curriculum. Additionally, teachers have increased self-efficacy with both paleontology and AI concepts and practices and are interested in learning more about these topics.

**Funding Sources** Funded by the U.S. National Science Foundation (NSF) ITEST (Innovative Technology Experiences for Students and Teachers) project 2147625, Bruce J. MacFadden PI/PD.

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Paleontological Management Poster Session (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**TO SCREEN OR NOT TO SCREEN: COMPREHENSIVE MITIGATION MEASURES FOR CONSTRUCTION PROJECTS**

Macias, Melissa K., Shi, Chris, Ollendorf, Amy L.

Paleontology, Applied Earthworks Inc, Fresno, California, United States

The California Environmental Quality Act (CEQA) requires detailed technical studies to determine the effects of a proposed development or redevelopment project. If the studies determine that significant environmental impacts may occur from the proposed actions, CEQA requires alternative plans to avoid or mitigate those impacts. Measures are designed for a project to result in less than significant impacts when mitigation is included. Mitigation measures (MMs) for paleontology consider near-surface and exposed geologic formations, known fossils, and management recommendations from the technical studies. For a project area with high paleontological sensitivity, MMs typically include construction monitoring, recovery, and analysis of collected resources, and accession of fossilized specimens into an accredited repository.

Microvertebrates and other small paleontological resources are vitally important to understanding the paleoenvironment. Furthermore, fossil localities within project areas can be considered ephemeral to a large extent since they can be significantly reduced or destroyed by ground-disturbing construction activities. However, many MMs do not include requirements to collect and screen sediments that are likely to yield such resources. Instead, field monitors primarily focus on recovering and preserving large and easily discernible fossils found during construction. Our study utilizes MMs, monitoring plans, and final post-field monitoring reports for actual monitoring projects already completed or ongoing in California to assess the presence/absence of MMs with specific instructions for the collection and processing of micro- and small fossils.

Our preliminary results indicate that MMs in half of the total number of plans required screening for micro- and small fossils yet nearly all of the projects' monitoring plans included procedures for their recovery. In contrast, screening had been conducted in less than half of the assessed post-field monitoring reports, with micro- and small fossils recovered in only 17%. In order to fully capture the breadth of paleontological information, agencies responsible for CEQA compliance consistently should approve and enforce MMs that address micro- and small fossils. By omitting such measures, paleoenvironmental reconstructions are skewed in favor of macroscopic specimens while failing to protect many other non-renewable paleontological resources.

**Funding Sources** Funding for this project was provided by Applied EarthWorks, Inc.

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Technical Session 16: Theropods - I (Saturday, October 21, 2023, 8:00 AM)

### A NEW DROMAEOSAURID FROM THE HELL CREEK FORMATION (MAASTRITCHIAN) OF NORTH DAKOTA WITH POSSIBLE TIES TO THE CLADE UNENLAGIINIA

Maddox, Hannah M.[1], Boyd, Clint A.[2], Drumheller, Stephanie K.[1]

[1]Earth and Planetary Sciences, University of Tennessee, Jonesborough, Tennessee, United States, [2]Fossil Resource Management Program, North Dakota Geological Survey, Bismarck, North Dakota, United States

The recent discovery of an unusual, elongate metatarsal from the Hell Creek Formation (North Dakota, USA) provides evidence for a new species of North American dromaeosaur with either Asian or South American affinities. The holotype (NDGS 9909) consists of a nearly complete left metatarsal II, well-preserved besides some crushing damage on the proximal posterior end. The metatarsal is slender (15:1 width/length ratio), 143 mm in length, and unfused at the proximal end. The distal end is also distinctly ginglymoid, and the rugose contact surface between MII and MIII is characteristic of the subarctometatarsalian condition. Furthermore, there is a subtle flange of bone that would have covered a posterodistal portion of MIII. Phylogenetic analysis recovers this specimen as the basal-most member of Dromaeosauridae, in a sister taxon relationship with Dromaeosaurinae + Unenlagiinia. Additional morphological comparisons of features not included in the phylogenetic dataset suggest close ties to the Unenlagiinia (Unenlagiinae + Halszkaraptorinae), which, if true, would make this species both the first of this clade to be discovered in North America and the geologically youngest unenlagiine or halszkaraptorine thus far known.

The discovery of a new dromaeosaurid expands our knowledge of the diversity of dromaeosaurs in the last stages of the Cretaceous and gives us new insights into the diversity of small-bodied carnivores in the *Tyrannosaurus rex*-dominated ecosystem of the Hell Creek. The gracile morphology of this species, in contrast to the stockier Laurasian eudromaeosaurs, has been suggested to confer a greater cursorial ability in exchange for the grip strength seen in the pedal morphology of contemporary Laurasian dromaeosaurids. Additionally, the appearance of a predominantly Gondwanan or Asian dromaeosaur clade in Laurasia has biostratigraphic implications for the evolution and distribution of these groups throughout the late Cretaceous, suggesting that these two populations of dromaeosaurids were not as geographically isolated as previously thought. A dispersal event across a temporary land bridge or island-hopping from either Asia or South America into North America are the most likely mechanisms for the appearance of this dromaeosaurid in the Hell Creek.

**Funding Sources** Research was funded by the state of North Dakota and the Friends of NDGS Paleo.

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Technical Session 13: Fishes - Actinopterygians (Friday, October 20, 2023, 1:45 PM)

### THE EARLY FOSSIL RECORD OF FRESHWATER FISH IN APPALACHIA IS REVEALED BY A NEW EARLY PLIOCENE ASSEMBLAGE FROM THE GRAY FOSSIL SITE (TENNESSEE, USA)

Maden, Shay, Samuels, Joshua X.

Geosciences, East Tennessee State University, Jonesborough, Tennessee, United States

Pre-Pleistocene freshwater fish assemblages in the eastern United States are exceedingly rare, limited to only a handful of localities. The Gray Fossil Site in northeast Tennessee, an early Pliocene sinkhole fill, has yielded an abundance of vertebrate remains, including hundreds of fish specimens. Comparison with extant and fossil fish taxa reveals a depauperate ichthyofauna consisting of only two centrarchid taxa: *Micropterus* cf. *M. salmoides* (black bass) and *Lepomis* sp. (sunfish). This material represents the oldest centrarchid material from the eastern United States outside of Florida. As such, it has potential to inform understanding of centrarchid evolution and diversification. *Micropterus* are opportunistic predators that feed on fish and even terrestrial vertebrates such as frogs and salamanders as they increase in size. *Lepomis* are generally predators of aquatic insect larvae, small crustaceans, zooplankton, and other aquatic invertebrates. Gray Fossil Site *Lepomis* are "short-jawed" and lack robust pharyngeal jaws, suggesting they were non-specialized predators of aquatic invertebrates. Extant species of *Micropterus* and *Lepomis* occupy a variety of freshwater habitats but typically spawn in shallow, open water with soft substrate overlying gravels, which suggests these conditions may have been present in the sinkhole pond. The absence of other fish species that are ubiquitous in streams and rivers in the southeastern United States today indicates that the sinkhole pond was not connected to surrounding waterways by surface hydrology, limiting dispersal of these taxa into the pond. In addition to large numbers of disarticulated and unassociated bones, several articulated and partially articulated fish specimens have also been recovered and show minimal to no evidence of postmortem disarticulation or scavenging. This suggests a cold and/or anoxic hypolimnion within the sinkhole pond, which would prevent bloating and access by scavengers. Invertebrate scavengers commonly found in North American aquatic ecosystems such as crayfish and aquatic snails have not been recovered from the site. Osteological thin sectioning of fossil fish atlantes suggests slow growth rates in Gray Fossil Site fishes and small overall size for their age, possibly due to limited surface area or other suboptimal conditions within the pond they inhabited.

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Technical Session 17: Afrotheria & Mammal Macroevolution (Saturday, October 21, 2023, 8:00 AM)

## EXPLORING THE FUNCTIONAL SIGNIFICANCE OF TOOTH ROOT SHAPE, SIZE, AND ORIENTATION IN MODERN TRIBOSPHENIC MAMMALS AND JURASSIC CLADOTHERIANS

Magallanes, Isaac[1], Li, Peishu[2], Martin, Thomas[3], Luo, Zhe-Xi[2]

[1]Committee on Evolutionary Biology, University of Chicago Division of the Biological Sciences, Chicago, Illinois, United States, [2]The Department of Organismal Biology and Anatomy, The University of Chicago, Chicago, Illinois, United States, [3]Section of Paleontology, Institute of Geosciences, Universität Bonn, Bonn, North Rhine-Westphalia, Germany

Mammal teeth and jaws have served as powerful indicators for understanding their life history, ecomorphology, and evolution. This is because the great shape diversity of mammalian teeth and jaws are correlated to feeding function and dietary ecology. To date, there are extensive studies on the transformation of tooth crowns and jaws across major phylogenetic transitions and ecological diversifications. One example is the evolution of tribosphenic molars in therian mammals, that granted versatile and efficient grinding and shearing functions compared to the molars of pre-tribosphenic therians. However, almost no studies have addressed the other half of dental morphology - the tooth roots, which are integral to dental anatomy and essential for the masticatory function of all toothed mammals. Tooth roots are positioned directly below the enamel-covered tooth crown and held by periodontal ligaments in the root alveoli of the jaws. Tooth roots and surrounding soft tissues experience complex loading regimes during mastication, and they help transmit sensory afferents to the central nervous system for sensorimotor coordination required for precise occlusion. Human tooth root morphology has been examined extensively in dental clinical practice and research. However, diversity of tooth root morphologies of major mammalian groups remains poorly documented. Even more limited is our understanding of tooth root form-function relationship in the Mesozoic stem therians such as cladotherians. Here, we present a new study on the tooth root morphology of therian mammals, the metatherian *Monodelphis domestica* (short-tailed opossum) and eutherian *Tupaia glis* (common tree shrew). We provide fresh data on patterns of variation and covariation between the mandibular tooth roots and crowns in metatherian and eutherian tribosphenic mammals, and related cladotherians of the Mesozoic. We explore the functional implications of morphometric measurements like tooth root surface area and root orientation in relation to the distribution of estimated maximum bite forces along the postcanine rows and the jaws. We also note patterns of increasing procumbence of anterior teeth in *M. domestica* where the roots of p1 to i1 are more procumbent relative to other post-canine teeth (p2 to m4). This pattern is less pronounced in *T. glis*, and so we discuss the potential driving factors including differences in function and life history inherent to the sampled taxa.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**EXCEPTIONALLY RAPID TOOTH DEVELOPMENT AND ONTOGENETIC CHANGES IN THE FEEDING APPARATUS OF THE KOMODO DRAGON**

Maho, Tea, Reisz, Robert

Biology, University of Toronto Mississauga, Mississauga, Ontario, Canada

The patterns of dental development and replacement in extinct amniotes, including synapsids and reptiles, have attracted a lot of attention. Notable among these are the Paleozoic hypercarnivorous synapsids and the Mesozoic theropod dinosaurs, generally considered to have true ziphodonty, strongly serrated carinae with dentine cores within an enamel cap. To gain a better understanding of their life history and feeding behaviors, we undertook a comparative dental histological analysis of the extant apex predator, the Komodo dragon, in combination with computed tomography of intact skulls. This study allowed us to reconstruct the dental morphology, ontogeny, and replacement patterns in the largest living lizard with known feeding behavior. *Varanus komodoensis* is the only extant terrestrial vertebrate to exhibit true ziphodonty, a feature found in theropod dinosaurs as well as in the early synapsids *Dimetrodon grandis* and *Mesenosaurus efremovi.* X-Ray computed tomography revealed that *V. komodoensis* maintains up to five replacement teeth per tooth position, while histological analysis showed an exceptionally rapid formation of new teeth, every 40 days. A similar pattern of rapid tooth replacement is also seen in *M. efremovi*, whereas theropod dinosaurs have been found to have longer replacement rates. Additionally, a dramatic ontogenetic shift in the dental morphology of *V. komodoensis* was also discovered, likely related to changes in feeding preferences and habitat. The juveniles have fewer dental specializations, lack true ziphodonty, are arboreal and feed mostly on insects, whereas the adults have strongly developed ziphodonty, are terrestrial apex predators and exhibit a defleshing feeding behavior. Surprisingly, the sister taxon of the Komodo dragon, the crocodile monitor (*Varanus salvadorii),* had four replacement teeth per tooth position, with a similarly rapid replacement rate, but the serrations are modest with shallow dental cores. In addition, we found evidence that the ziphodont teeth of *V. komodoensis* have true ampullae (interdental folds), similar to those found in most theropod dinosaurs, which are thought to increase the resistance of the serrations to damage. The Komodo dragon appears to be the only extant terrestrial predator in which these dental specializations have been noted, making it particularly useful in reconstructing feeding behaviors in extinct taxa.

**Funding Sources** Natural Sciences and Engineering Research Council of Canada (NSERC) - Canada Graduate Scholarships – Master's (CGS M)

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Technical Session 1: Sauropod & Ornithischian Dinosaurs (Wednesday, October 18, 2023, 8:00 AM)

**DIVERSITY CHANGE THROUGH TIME AND SPACE IN THE UPPER JURASSIC MORRISON FORMATION, WESTERN USA**

Maidment, Susannah

Fossil Reptiles, Amphibians and Birds Section, Natural History Museum, London, London, United Kingdom

Understanding how biodiversity has changed through time is a central tenet of paleobiology. Recent studies have suggested that biases in the terrestrial fossil record prevent us from reconstructing biodiversity change on a global scale, and that regional studies carried out at high temporal resolution are needed if we are to accurately reconstruct past biodiversity patterns. The Upper Jurassic Morrison Formation of the western USA crops out over 1.2 million square km, extends for 12 degrees of latitude, and is chronostratigraphically correlated across this area, providing the ideal case study to examine biodiversity change through space and time in the Late Jurassic. Tetrapod occurrences from the Paleobiology Database were chronologically mapped using direct sedimentological observation and the literature. Raw and sample-standardized diversity were plotted through time and with latitude, and the ranges of dinosaur taxa were reconstructed in ArcGIS. Sample-standardized diversity increased through time, with no evidence for a diversity decrease prior to extinction of the Morrison fauna at the end of the Jurassic. Highest raw diversity is found in systems tracts characterized by waterlogged floodplain facies, indicating a sequence stratigraphic control on fossil preservation. Sample-standardized diversity peaked in the middle of the Morrison basin, decreasing at higher and lower latitudes, consistent with previous suggestions that the center of the basin might have been wetter than the margins, but contrasting strongly with the latitudinal biodiversity gradient across the same area today. The ranges of species of *Allosaurus* and *Camarasaurus* do not overlap, indicating geographical partitioning, and there is some indication of a northwestern and southeastern fauna, albeit with several shared taxa. High resolution climate models for North America through the Late Jurassic are needed to examine the causative mechanisms behind these diversity patterns.

**Funding Sources** The foundations of this research were carried out when the author was in receipt of an Imperial College Research Fellowship

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Technical Session 16: Theropods - I (Saturday, October 21, 2023, 8:00 AM)

## NEW ADDITIONS TO THE EARLY FOSSIL RECORD OF CAENAGNATHIDS IN NORTH AMERICA

Makovicky, Peter[1], Cifelli, Richard[2], Zanno, Lindsay E.[3], Cullen, Thomas[4]

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Caenagnathids are toothless pennaraptoran theropods with increasing diversity in the Campano-Maastricthian of the Western Interior Basin (WIB). The clade also has a growing fossil record in Asia including giant taxa such as *Gigantoraptor erlianensis*. In contrast to their Campano-Maastrichtian record, the pre-Campanian caenagnathid record in North America is restricted to the juvenile holotype specimen of *Microvenator celer* from the Early Cretaceous Cloverly Formation.

The stratigraphic gap in the North American caenagnathid record between *Microvenator* and Campano-Maastrichtian taxa was until recently only punctuated by eggs and eggshell referred to the ootaxon *Macroelongatoolithus carlylei* from the Cenomanian Mussentuchit member (MM) of the Cedar Mountain Formation and the penecontemporaneous Wayan Fm. of Idaho. Nearly complete eggs from those units exhibit sizes consistent with being laid by a *Gigantoraptor*-sized animal.

In 2012, a Field Museum crew excavated a partial skeleton of a giant caenagnathid from the MM. With a tibial length of 95 cm, this specimen is very close in size to *Gigantoraptor*. This discovery also permits reinterpretation of a small theropod skeleton collected from the MM by the Sam Noble Museum as a juvenile specimen of the same species based on several femoral synapomorphies. Thin-sections were made from femora of both individuals for osteohistological analysis. The histology of the smaller individual exhibits a single annual growth mark and laminar to plexiform fibrolamellar bone throughout the cortex, consistent with being a juvenile. The osteohistology of the large individual is unusual. It possesses a comparatively thin cortex, with nearly uniform laminar fibrolamellar bone, and only two annual growth marks located near the periosteal margin.

Synapomorphies of caenagnathids are also evident in an isolated femur from the Antlers Fm. of Texas, documenting the first caenagnathid specimen from that unit and a major geographic range extension for the clade in the Early Cretaceous. This find also adds to the significant taxonomic overlap between the Antlers and Cloverly Formations, which share a majority of their dinosaurian genera. Body mass estimates calculated for this femur, and for the large MM specimen, result in an optimized ancestral body size of over 100 kg for Caenagnathidae.

**Funding Sources** This research was supported by National Science Foundation awards 1925973, 1925884 to LEZ and PJM, respectively, and by funding from the Field Museum to TMC.

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Technical Session 13: Fishes - Actinopterygians (Friday, October 20, 2023, 1:45 PM)

**'I'M NOT LIKE THE OTHER GILLS': REEVALUATION AND REIDENTIFICATION OF *PLATYLITHOPHYCUS* SPECIMENS FROM THE NIOBRARA OF WESTERN KANSAS**

Maltese, Anthony E.[1], Liston, Jeff[2]

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With its initial discovery in 1948 near Monument Rocks, *Platylithophycus cretaceus* had been interpreted as an alga and a sepiid until Bronson identified it as part of the gill apparatus of an elasmobranch. Since this identification of UNSM IP 16868, other specimens purported to represent parts of disembodied gill assemblages have been recovered by private collectors from the lower Niobrara Chalk of Western Kansas and assigned the identification of *Platylithophycus* when donated to museum collections. However, two of these more recently collected specimens, from between Hattin's marker units 5 and 7 (both late Coniacian), appeared to differ in significant details from the historically collected specimens. An evaluation of all four known specimens was undertaken using ultraviolet light. Examination revealed that the historic George Sternberg specimen FHSM VP-19365 not only matched the osteology of the holotype, but that it was excavated by the same collector at the same time and likely from the same locality as the holotype, inferred to be in the range of Hattin's marker units 9 to 11. As parts of the holotype are also recorded as residing in the collections of up to 5 other institutions, it seems probable that FHSM VP-19365 represents yet more parts of that same holotype specimen. In contrast, the two more recently collected specimens (FHSM VP-19363 and FHSM VP-19874) attributed to this taxon were found to have a completely different structure, lacking the hexagonal tesserae of chondrichthyans and instead displaying bony gill arch elements with large gill rakers. The preservation of isolated gill basket material in marine deposits is not unknown, having been reported, for example, in specimens of the Middle Jurassic suspension-feeding pachycormid *Leedsichthys* from Peterborough, England and material from the Upper Jurassic of Solnhofen, Germany. The two new specimens appear to represent a similar mode of preservation occurring in the Upper Cretaceous, the gill raker characteristics indicating that it is likely from another large suspension-feeding bony fish. In terms of suspension-feeding bony fish from the Niobrara, the material does not appear to match the morphology of the extremely rare *Megalocoelacanthus*, but the specimens do coincide stratigraphically with some of the earliest observed occurrences of the suspension-feeding pachycormid *Bonnerichthys gladius*, although the morphology of that animal's gill rakers are thus far undescribed.

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Technical Session 18: Synapsids (Saturday, October 21, 2023, 8:00 AM)

**FIRST CRANIAL REMAINS OF THE OPHIACODONTID "*CLEPSYDROPS*" FROM THE UPPER CARBONIFEROUS OF LINTON, OHIO, AND THE DEPOSITS'S PRECOCIOUS AMNIOTE RECORD**

Mann, Arjan[1], Hook, Robert W.[2], Pierce, Stephanie E.[3]

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The Upper Carboniferous (Moscovian) locality of Linton, Ohio, has produced a handful of early synapsid specimens, three of which were referred to the poorly known genus *Archaeothyris*, and two others that are the basis for the recently described edaphosaurid *Melanedaphodon hovaneci*. In addition, a recently prepared synapsid skull from Linton includes the cheek and mandibular elements of a relatively large ophiacodontid. Anatomical features shared by this specimen and Ophiacodontidae include: 1) teeth that lack labio-lingual compression and are recurved closer to the apices, 2) foramina with posteroventrally oriented ducts on the lower mandible, and 3) a proportionally high suborbital region of the jugal indicating a triradiate morphology. The new Linton material is indistinguishable from more complete but undescribed ophiacodontid specimens from Garnett (Kasimovian), Kansas, provisionally referred to *Clepsydrops*. The Garnett and the Linton material, along with the *Clepsydrops* type material from the Danville Bonebed (Kasimovian) of Illinois, exhibit a splenial

contribution to the mandibular symphysis and rugose ornamentation on the lower mandible. These features appear to be absent in the Early Permian *Varanosaurus* and *Ophiacodon*. The new Linton specimen promotes a re-examination of the early ophiacodontids *Clepsydrops*, *Archaeothyris*, and *Echinerpeton*. Preliminary results suggest that distinctions between *Archaeothyris* and *Clepsydrops* are size-related and, therefore, the taxa may be congeneric or at least presently inadequately diagnosed. *Echinerpeton* remains valid because it has several autapomorphic features among Ophiacodontidae, including non-recurved, blunt, bullet shaped teeth and neural spine hyper-elongation. Although terrestrial vertebrates, and amniotes in particular, are the rarest of all fossils at Linton, past and recent discoveries reveal the earliest and most diverse Moscovian amniote assemblage known. It is comprised of the recumbirostrans *Odonterpeton, Brachydectes*, and likely *Tuditanus*; the parareptile *Carbonodraco*; the eureptile *Anthracodromeus*; and three synapsids, the edaphosaurid *Melanedaphodon*, the ophiacodontid *Clepsydrops*, and a varanopid that awaits description. This diversity warrants further investigation into the wetland paleoecology of Carboniferous amniote communities.

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Technical Session 14: Crocodylomorphs & Turtles (Friday, October 20, 2023, 1:45 PM)

**A NEW CROCODYLOMORPH FROM THE CARNIAN GHOST RANCH FORMATION WITH IMPLICATIONS FOR THE SOLIDOCRANIAN GHOST LINEAGE**

Margulis-Ohnuma, Miranda, Ruebenstahl, Alexander A., Bhullar, Bhart-Anjan S.

Earth and Planetary Sciences, Yale University, New Haven, Connecticut, United States

We describe the skull and incomplete postcrania of the Late Triassic crocodylomorph YPM 41198 from a block of *Coelophsyis bauri* recovered in 1948 from the *Coelophysis* quarry at Ghost Ranch, NM. YPM 41198 includes a nearly complete anteroposteriorly crushed rostrum, partial skull roof and posterior left mandible, osteoderms, and elements of the left hindlimb. Notable features include a relatively short snout, a slit-like antorbital fenestra, a longitudinally concave ventral edge of the jugal, and an arched dorsal edge of the surangular. These characteristics are consistent with strengthening and reinforcement of the facial region. The specimen also shares several features of the frontal with *Hesperosuchus agilis*, the taxon to which this specimen was tentatively assigned decades ago.

Phylogenetic analyses using parsimony in TNT with four alternate assigned outgroup taxa and both equal and implied weights (k=6, k=12, k=24) place YPM 41198 either sister to *Hesperosuchus*, outside of the clade containing AMNH 6578 (the holotype) and CM 29894, or as an early-diverging member of Solidocrania, sister to *Junggarsuchus sloani* and *Phyllodontosuchus lufengensis*. To avoid the possibility of creating a polyphyletic *Hesperosuchus* and based on suitable anatomical difference, we will assign this specimen to a new genus. As at least the second non-crocodyliform crocodylomorph from Ghost Ranch, the classification of this fossil as a new taxon demonstrates the co-existence of similarly sized crocodylomorphs at this locality. The latter of our phylogenetic results may help to fill the current Solidocranian ghost lineage, as the non-crocodyliform crocodylomorphs most closely related to crocodyliforms known prior to this work were known only from the Jurassic, yet the oldest crocodyliforms date back to the Norian of the Triassic.

**Funding Sources** Yale Earth and Planetary Sciences: Karen L. Von Damm ‘77 Undergraduate Research Fellowship

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Technical Session 3: Fishes & Amphibians (Wednesday, October 18, 2023, 8:00 AM)

**TETRAPODOMORPH PHYLOGENY INCLUDING THE ORIGINS OF LISSAMPHIBIA AND AMNIOTA: GO BIG OR GO HOME**

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Everything in biology and its applications (such as medicine and bionics) relies on evolutionary biology, which itself relies on phylogenies. Up to now, amniote phylogeny has consistently been studied as a separate issue from its context, the phylogeny of early limbed vertebrates. The almost complete lack of overlap between the matrices used to study these two questions is a problem because the membership of

Amniota is not as clear-cut as used to be thought and because outgroup selection is crucial to analyzing ingroup phylogeny.

Starting from a matrix of early limbed vertebrates, I have greatly enlarged the character and taxon sample into Amniota (and in other directions), paying special attention to character redundancy and unexpected state distributions. Very preliminary results from a computationally challenging analysis support Adelospondyli in Colosteidae, Anthracosauria rootward of Temnospondyli, and Amniota as a fairly close relative of Lissamphibia. The pan-amniote stem seems to consist of *Brouffia* and maybe *Cephalerpeton*. Diadectomorpha is found nested inside Pan-Mammalia, next to a novel edaphosaur-ophiacodont clade. Pan-Mammalia further appears to contain caseasaurs, varanopids, sphenacodonts and at least *Coelostegus*. “Parareptiles” are sprinkled all over Amniota. *Opisthodontosaurus* lies closer to *Captorhinus* than *Euconcordia* does. On the amphibian side, most “tuditanomorphs” form the sister-group of the recently redescribed *Odonterpeton*; together they lie outside a clade bifurcated into (*Joermungandr* (Lysorophia (Albanerpetidae, Lissamphibia))) and (Brachystelechidae (*Scincosaurus* (Diplocaulidae (Urocordylidae, Aïstopoda)))), although the fact that Aïstopoda is clearly misrooted is strong evidence that it really belongs elsewhere and that, at least, *Oestocephalus* should be redescribed. In some trees, *Steenerpeton* is the sister group of Tetrapoda, followed by Seymouriamorpha + *Solenodonsaurus*, then Chroniosuchia and then Temnospondyli and/or *Casineria*. Within Temnospondyli there is support for Dissorophoidea + *Iberospondylus* as the sister group to all the rest. Lissamphibia and its gross phylogeny agree with results from molecular data. No other part of the tree can be compared.
The clustering of small-bodied taxa around the amniote base argues in favor of the old idea that a size squeeze is causally connected to the origin of the amniotic egg. An earlier, milder size decrease appears to mark the origin of less than strictly aquatic lifestyles.

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Paleontological Management Poster Session (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**SYSTEMATIC PALEONTOLOGICAL INVENTORY OF NEWLY ACQUIRED LANDS AT PETRIFIED FOREST NATIONAL PARK REVEALS UNPRECEDENTED DIVERSITY OF LATE TRIASSIC TERRESTRIAL VERTEBRATES**

Marsh, Adam[1], Beightol, Charles V.[2], Toth, Natalie G.[3], Kligman, Ben T.[1], Parker, William G.[1]

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Petrified Forest National Park (PEFO) continues to be one of the best places in the world to visit and research Upper Triassic terrestrial sedimentary rocks and the fossils they contain, including the permineralized conifer wood for which the park is named. As a result of a 2004 boundary expansion, PEFO acquired ~50,000 acres of former ranch land within the new park boundary. The park’s General Management Plan requires archaeological and paleontological inventories of new lands before visitors are allowed to access them, and the latter was conducted over three years starting in 2016. This was paid for using $215,395 in National Park Service Natural Resource funds and a 65% match from the park and its cooperating association. The inventory project paid for and was otherwise supported by three field paleontologists, eight student interns, eight volunteers, and three youth conservation groups. These efforts over three years resulted in hundreds of scientifically significant fossils collected as voucher specimens from 353 field sites equaling 72 new official fossil localities, and from discrete stratigraphic intervals spanning 20 million years of the Chinle Formation. Additionally, the inventory project identified parcels and localities with low, medium, and high monitoring priority and established two localities as ‘day dig’ public engagement opportunities with the park’s cooperating association. The next steps are to geologically map and extend the existing stratigraphic framework from within the former park boundary to these new lands. Additionally, the newly collected specimens are being curated and made available for research, and targeted fieldwork will continue with a focus on the most scientifically important sites found by this inventory; for example, those that have sextupled the known dinosauromorph specimens from PEFO and localities that produced the earliest frogs in North America and the world’s oldest caecilian. The three-year inventory of new lands at PEFO discovered Triassic fossils that are reshaping our understanding of terrestrial vertebrate evolution in the early Mesozoic and stands as an important example for

inventorying National Park Service lands for significant paleontological resources.

**Funding Sources** National Park Service, Natural Resources; Petrified Forest National Park; Petrified Forest Museum Association.

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Technical Session 9: Sauropsids (Thursday, October 19, 2023, 1:45 PM)

## CONSIDERING ALL TOOTH-BEARING BONES DEMONSTRATES ELEVATED TOOTH COMPLEXITY AMONG EARLY TETRAPOD HERBIVORES

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Early tetrapods encountered multiple food sources when they first emerged onto land, and tetrapods subsequently evolved dentitions that allowed them to exploit numerous food types. Conventional wisdom suggests that “simple” tooth shapes equate to a faunivorous diet and “complex” tooth shapes indicate a plant-eating diet. However, the evolution of herbivory through tetrapod history has produced numerous approaches to plant-eating, including turtle-like beaks, multiple maxillary and dentary tooth rows, dentigerous palatine and pterygoid bones with clustered, bulbous teeth, and multi-cusped molariform teeth. Recent work has taken a more holistic approach, considering not just tooth shape, but how tooth orientation and arrangement, and jaw shape work as a system to solve the problem of processing plant material. While previous analyses of tooth complexity have been limited to marginal teeth, this study quantifies the complexity of the dentition and the arrangement of teeth on all the tooth-bearing bones as one measurable unit. Using micro-computed tomography (μCT), surface scanning, and photogrammetry, we rendered three-dimensional (3D) meshes of fossil tetrapod tooth-bearing bones of the skull and dentitions, including early herbivores such as diadectids, captorhinids, edaphosaurids, and caseids. Measures of tooth complexity (OPCr) and surface topography (DNE and RFI) were used to compare the shape of dentitions and their arrangement across early tetrapods. These measurements were then placed within a comparative framework of living animals. Slicer was used to investigate if and how biomechanical function changes between tooth shapes in extinct organisms. Together, these methods demonstrate that, while early herbivorous tetrapods have seemingly simple individual teeth, their teeth, tooth arrangements, and tooth-bearing bones work together as highly complex systems to process plant matter. This challenges previous notions of tooth complexity and its relation to diet and highlights the need for a more nuanced interpretation of the dentitions and diets of fossil animals.

**Funding Sources** Field Museum of Natural History; National Science Foundation Graduate Research Fellowship Program; The University of Chicago

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Technical Session 20: Marine Mammals & Bats (Saturday, October 21, 2023, 1:45 PM)

## FOSSIL BALEEN WHALES (CETACEA, MYSTICETI) SHOW THAT BRAIN SHAPES ACHIEVED MODERN BEFORE BALEEN EVOLVED

Matsui, Kumiko[1], Pyenson, Nicholas[1], Tsuihiji, Takanobu[2], Ando, Tatsuro[3]

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Baleen whales (Cetacea, Mysticeti) appeared in the latest Eocene, although these early baleen whales had teeth and lacked true baleen for filter-feeding. The earliest baleen whales also possessed organs for olfaction, which they inherited from their terrestrial ancestors and continue to possess today. By contrast, olfactory organs are absent in every living lineage of toothed whales (Odontoceti), the sister group to mysticetes, implying that olfaction was lost in odontocetes (all crown cetaceans have also lost the ability to taste, as well). As with other mammals, olfaction in cetaceans is functionally regionalized in the olfactory bulb, which can be inferred directly from natural endocasts of the braincase and computed tomography (CT) scanning.

To understand the evolution of olfactory bulbs (OB)

and their potential connection to brain evolution, we used CT scanning to examine eight fossil and modern mysticetes, one archaeocete, three odontocetes, and five modern artiodactyls. In addition to morphological comparisons, we analyzed the evolutionary rate of these proxies to compare the timing of brain morphological changes, OB size, and the encephalization quotient (EQ) for further understanding of the relationships between morphological changes and the emergence of baleen.

We determined that the OB is present in all the extinct and extant Mysticeti. However, the size and length of the olfactory tract varied among the groups. In the stem mysticetes, OB size is greater, and the olfactory tract is longer than that of all toothed baleen whales or crown baleen whales in general. In EQ, we could not find any significant changes in the clade of Mysticeti. We could only identify a predominant increase in Odontoceti. On the other hand, evolutionary rates of the volume and length of olfactory bulbs significantly changed within the clade of crown Mysticeti + Aetiocetidae. In the cerebrum size of endocasts, we could not identify any significant changes. However, the size of the cerebrum size has a trend toward a larger size. The clade of crown Mysticeti and Aetiocetidae has a similar proxy of cerebrum size, but some aetiocetids have a bigger size of cerebrum compared to crown Mysticeti. Our work shows that baleen whale brains and sensory organs evolved in strongly regionalized ways, likely decoupled from innovations such as filter-feeding and extreme gigantism.

**Funding Sources** JSPS 19J00741/21K14031, the Sasakawa Scientific Research Grant 2018-6028, the Joint Usage/Research Center for Drilling Earth Science (JURC-DES) (19B054).

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**THE HUMPTY DUMPTY PROTOCOL: PREDICTING THE INITIAL VOLUME OF EGGS FROM CRUSHED REMAINS**

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Burial, sediment deposition, and lithostatic compaction can deform fossil eggs from their original shape and volume. Egg volume is an important variable for understanding reproductive output. Here we test to what degree one can accurately estimate original egg volume from the dimensions of crushed remains. We conducted two different experiments with chicken eggs: 1) 48 unaltered eggs were crushed while atop a sand surface then classified into six deformation grades, with zero being nearly intact and five being severely deformed and 2) 35 eggs had their liquid contents removed and replaced with and classified by varying levels of sediment, from empty to completely filled - before being buried in clay-rich sediment and crushed using a hydraulic press. In both experiments, breadth and width of crushed eggs were used to predict the original volumes using an allometric formula. Predicted volumes were then compared with pre-crushed volumes. For all 48 unaltered eggs, the adjusted R-squared of 0.128 was obtained. After class five eggs were excluded from the dataset, it increased to an $R_a$-squared to 0.24. Eggs with modest deformation (class 0-2) had an adjusted $R_a$-squared of 0.54 (N=12). For the 35 filled eggs, an $R_a$-squared of 0.44 was calculated. Empty eggs were observed to have collapsed inward along their breadth possibly skewing the results, and when they were taken out of the dataset, $R_a$-squared value increased to 0.58. As deformation is uncorrelated with initial volume, this means that the linear model can explain 54-58% of the variation in the predicted volumes in an identifiable subset of crushed eggs.

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Technical Session 10: Euarchontoglires & Xenarthra (Friday, October 20, 2023, 8:00 AM)

**NEW EVIDENCE FOR SLOTH FAMILY UNITS IN *PAROCNUS* (MAMMALIA: PILOSA) FROM LATE QUATERNARY CAVE SYSTEMS IN HISPANIOLA (DOMINICAN REPUBLIC, HAITI)**

McAfee, Robert K.[1], Beery, Sophia[2], Macias, Melissa[3], Almonte, Juan[4]

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Evidence of fossil sloths existing in family units (minimum one adult and one juvenile) or being gregarious has increased over the last two decades. The occurrences are not taxonomically isolated, with examples occurring in representatives from each of the three major families (i.e. Megalonychidae, Megatherridae, Mylodontidae), suggesting that behaviors relating to parenting existed for most extinct sloths. More recent investigations into intraspecific variation and potential sexual dimorphism within the Caribbean sloths from Hispaniola also suggests the possibility of family units for members of *Parocnus serus*, with multiple sites consisting of two differently sized adults found in the presence of juvenile remains. These findings primarily consisted of partial skeletons with minimal juvenile remains (e.g. one element with unfused epiphyses). Cueva Tridems (Three Lakes) is a trio of underwater karst caves from the western Altagracia Province town of Bávaro, with two rooms producing sloth remains almost entirely belonging to *Parocnus* and a final room with no remains. Fossils from Room 1 have an MNI of 3 based on the right scapula and consist of two adults and one juvenile, all of which correspond to *P. dominicanus* and represent the first occurrence of a family unit for the species. The large adult remains are few, but the other adult (Bella) represents the most complete individual of *P. dominicanus* found anywhere to date (61%). The juvenile (Baby Bel) is a moderately complete skeleton (20%), and is a very young individual, not a neonate, based on the skeletal morphology lacking secondary ossification in most elements and presence of open sutures that typically close early in development (i.e. axis, C2). Although consistent size dimorphism hasn't been established for sloths, Bella is assumed to be female given the association with Baby Bel and completeness of those two individuals. Specimens in Room 2 exhibit a greater degree of wear and are composed of three species: *P. dominicanus*, *P. serus*, *Acratocnus ye*, and marks the first co-occurrence of both *Parocnus* species at the same locality. Aside from the singular right femur of *Acratocnus*, *Parocnus* is represented by two or three adults and two juveniles. The room also possesses a number of coprolites of a size that can only be associated with the sloths, and in amounts greater than a single use of the cave, which suggests that *Parocnus* may have utilized the caves as dens with their offspring.

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**THE IMPACT OF INSECTS ON DINOSAUR BONES FROM THE GRAY ASH QUARRY (YELLOW CAT MEMBER OF THE CEDAR MOUNTAIN FORMATION, EARLY CRETACEOUS, BAREMMIAN), NEAR ARCHES NATIONAL PARK, UTAH, USA**

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The Yellow Cat Mbr of the Cedar Mountain Fm has been a hotbed of dinosaur discovery in Utah over the past 30 years. The 125 Ma Yellow Cat Mbr consists primarily of a silty mudstone diamictite composed of silty mudstones to fine-grained sandstones (largely derived from the underlying Morrison Fm.) representing fluvial and related overbank environments.

Fifty-three specimens were collected from the Gray Ash Quarry. All are broken and some consist only of cm-scale pieces of laminar bone. Breakage is attributed to trampling, a common taphonomic factor within the Yellow Cat Mbr. Bones from the site are so fragmentary that they cannot be identified to elements, aside from being part of a rib or the shaft of a long bone. They are likely dinosaurian based on size. Teeth are also found at the quarry but are not included in this study.
At least 50% of the bones exhibit traces, including pits, holes, furrows, channels, and borings. Furrows and channels range from 1-10 mm wide with most 4-6 mm wide. Pits, holes, and borings have elliptical openings 2-14 mm in diameter. Some furrows and channels lead into borings. Borings penetrate laminar bone and meander through cortical bone. Bioglyphs consisting of arcs 0.5 mm wide are common in furrows and channels. These bioglyphs are interpreted as mandible marks created as insects gouged the bone. The impact of the traces on the bones range from moderate to severe on the external surfaces of bones; many are also riddled internally by borings. Frass consisting of minute bone fragments is common in trace fillings and matrix adjacent to bones. Burrows 6-12 mm in diameter, sometimes contiguous with the traces, are also found in the surrounding matrix.

These traces are assigned to the ichnotaxon Cubiculum sp. Frass-filled burrows on the bones demonstrate infestation occurred while the bones were buried in the silty clays prior to lithification and that the bones were not transported post-infestation. The unusually high degree of damage suggests (1) the tracemaker was abundant and thriving at the site, and (2) that food resources (bone) was in short supply.

The morphology of the traces indicates termites are not the trace maker. The traces share several characters with traces made by dermestid beetle larvae but lack pupation chambers and are several times larger. Similar traces have been reported from other Cedar Mountain Fm sites but the Gray Ash site better preserves bioglyphs that may be the key to identifying the trace maker.

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**VERTEBRATE ICHNOFOSSILS FROM JURASSIC NATIONAL MONUMENT, UPPER MORRISON FORMATION, UTAH - A PRELIMINARY CENSUS**

McCloskey, Jacob M.[1], Peterson, Joseph E.[1], Warnock, Jonathan P.[2], Dooms, Casey D.[3]

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The Cleveland-Lloyd Dinosaur Quarry at Jurassic National Monument has produced thousands of vertebrate remains from dinosaurs and other Jurassic fauna throughout the past century. However, vertebrate ichnofossils have been largely overlooked in this area of the Brushy Basin member. Here we report data on nine vertebrate ichnofossil localities in Jurassic National Monument as part of a small preliminary sample of ongoing work in the vicinity of the Cleveland-Lloyd Dinosaur Quarry. The stratigraphic and lithological data of known vertebrate traces can yield potential trends in preservational or biological biases in the track record of this area. Ichnofossil localities were recorded with a GARMIN™ GPSmap 76CSx handheld GPS unit and stratigraphic positioning was measured from the contact of the Brushy Basin member of the Morrison Formation and the overlying Buckhorn conglomerate. 3D scans of collected fossil casts of theropod specimens were conducted with a Next Engine Desktop 3D Scanner, Model 2020i. 3D models were developed and inverted to demonstrate the original footprint molds. The most common facies among ichnogenera were mud-lain, however most were preserved as natural sandstone casts from migrating river channels and flooding events depositing coarser sediment overtop of the original molds. Perhaps this is a result of a preservational bias as prints made in muddy sediment are more likely to preserve, remaining intact for longer time periods before migrating rivers deposited sand overtop of the tracks. Additionally, there may be a biological bias towards mud facies as animals seldom stepped in rivers carrying coarser sediment. While most identified track localities are attributed to sauropod-like *Brontopodus isp*. and *Parabrontopodus isp*., non-sauropod traces such as *Grallator isp*. and *Deinehichnus isp*. are the only ichnofossils found at higher stratigraphic positions in the Brushy Basin member; within ten meters below the base of the Buckhorn conglomerate wedge. In contrast, nearly all the sauropod traces were more than ten meters below the contact, most occurring between 13 and 25 meters beneath this point. Perhaps this represents a major change in local biodiversity towards the end of the Jurassic. While preliminary and based on a small dataset, this has led to further questions regarding population dynamics approaching the end of the Jurassic as well as preservational biases.

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**REASSESSMENT OF VERTEBRATE MICROFOSSILS FROM THE STRAIGHT CLIFFS FORMATION (TURONIAN-CAMPANIAN) OF SOUTHERN UTAH**

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The Straight Cliffs Formation of central southern Utah represents Cretaceous inland coastal plain to nearshore marine environments from the Turonian through earliest Campanian stages, a time of important but poorly understood faunal turnover. This interval represents the greatest sea-level high stands of the Cretaceous, during which time large portions of the former coastal fluvial plains were submerged, reducing the fossilization potential for terrestrial vertebrates and rendering the faunal diversity of the time difficult to study. There are currently no published macrovertebrate sites from the Straight Cliffs formation and the bulk of vertebrate fossils are represented by isolated teeth. These have been thinly reported on in the literature, particularly in regards to detailed morphology and geologic context. To date, most published information consists of faunal lists of specimens by general taxonomic attribution. These include reports of the presence of tyrannosauroid, dromaeosaur, "*Richardoestesia*," ceratopsid, "protoceratopsian," and hadrosauroid remains. Here, we reevaluate the dinosaur fauna of the Straight Cliffs Formation based on the tooth record. We also explore stratigraphic and geologic patterns of these assemblages, within the vast paleoenvironmental and temporal (~20 million year) span of the Straight Cliffs Formation. Our comparisons with recent discoveries in mid-Cretaceous formations across the Western Interior Basin demonstrate the presence of early thescelosaurids, at least one ceratopsian (likely *Zuniceratops*-grade, rather than ceratopsid) and basal hadrosauroids (comparable to *Jeyawati* and *Eotrachodon*) in the formation. The latter findings, hailing largely from the Turonian Smoky Hollow member, invite faunal comparisons to the coeval Moreno Hill Formation of New Mexico, and open a wider window on Laramidian dinosaur diversity during the Turonian. Besides small tyrannosauroids and "*Richardoestesia*," we also demonstrate the presence of several distinct dromaeosaurid morphotypes as well as teeth from other paravians.

**Funding Sources** This material is based upon work supported by the National Science Foundation award #1925973 to LZ

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Technical Session 6: Marine Reptiles (Wednesday, October 18, 2023, 1:45 PM)

### THE LAST TRIASSIC GIANT? A LATE RHAETIAN ICHTHYOSAUR FROM NEW YORK CANYON, NEVADA, USA

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Ichthyosaurs achieved their maximum size during the Late Triassic Period. The largest described genus, *Shonisaurus*, appeared in the latest Carnian and persisted into the middle Norian, though the exact timing of its extinction is not completely clear. In Europe, a series of recent publications have described disarticulated material that demonstrates that giant shastasaurid ichthyosaurs continued into the Rhaetian, and suggests that, at least in the Tethys, large-bodied ichthyosaurs may have persisted up to the end-Triassic extinction (ETE). This material implies that the absence of late Norian and Rhaetian occurrences in North America may result from sampling bias rather than a true ecological signal.

A recent discovery in New York Canyon (NYC) in the Gabbs Valley Range of Nevada, U.S.A., provides clear evidence of the persistence of giant ichthyosaurs in Panthalassa during the Rhaetian. Previous studies have reported isolated ichthyosaur elements from NYC, but these have never been adequately studied or described. Here we report new *in situ* vertebrate fossils from the late Rhaetian of the Gabbs Formation in NYC. The specimen comprises at least 17 semi-articulated ribs and two centra from a giant ichthyosaur, comparable in size and shape to the largest known examples of *Shonisaurus*. NYC is a well-studied fossiliferous marine reference section for the ETE and Triassic-Jurassic boundary with excellent ammonite biostratigraphic and $\delta^{13}C_{org}$ geochemical controls. The bone-bearing horizon falls within the latest Rhaetian ammonite biozone for Panthalassa, the *Choristoceras crikmayi* Zone, and is just 1.7 meters below the negative $\delta^{13}C_{org}$ excursion that marks the beginning of the ETE in this section. This specimen is the youngest shastasaurid ichthyosaur and indicates that these giant ichthyosaurs did not go extinct during the Norian in Panthalassa. Instead, they likely persisted until the ETE, perishing as a casualty of the mass extinction event.
**Funding Sources** Funding for this project provided by student research grants from the Paleontological Society and the Nevada Petroleum and Geothermal Society.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

### NEW LITOPTERN (PANAMERIUNGULATA; MAMMALIA) SPECIMENS FROM LA VENTA (MIOCENE; COLOMBIA) AND ECOMORPHOLOGY OF NEOGENE HERBIVORE COMMUNITIES ACROSS THE PANAMANIAN SEAWAY

McGrath, Andrew[1], Croft, Darin A.[2], Carrillo, Juan D.[3], Suárez Perez, María G.[4], Link Ospina, Andres[4]

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The middle Miocene fauna of La Venta, Colombia, represents the best-known, low-latitude (i.e., tropical), Cenozoic South American mammal fauna prior to the Great American Biotic Interchange (GABI). Herein, we present new litoptern specimens from La Venta and characterize the ecomorphology of Neogene mammalian herbivore communities in the Americas to examine geographic and temporal patterns in guild structure.

New specimens of the proterotheriids *Mesolicaphrium sanalfonensis* and *Villarroelia totoyoi* and the macraucheniid *Theosodon* sp. significantly increase our knowledge of these La Venta litopterns. Previously unknown elements include p1 and nearly the entire deciduous lower dentition of *M. sanalfonensis*, lower incisors of *V. totoyoi*, and p4 of *Theosodon* sp.

We coded medium and large herbivores (>1 kg) from five fossil sites (including La Venta) and three modern herbivore communities for three categorical ecomorphological traits (body mass, feeding height, molar morphology) to compare the ecological structure of herbivore community. These communities vary greatly in latitude (spanning Central and South America) and in time to explore geographic differences and changes across major biotic events, including the GABI and the Pleistocene megafaunal extinction). We calculated diversity (number of species), ecological richness (number of occupied ecocells), and ecological disparity (mean distance among ecocells) to characterize community structure.

La Venta is more taxonomically diverse and ecologically disparate than the tropical pre-GABI Central American fauna of Centenario, Panama. Extratropical, pre-GABI South American faunas of Santa Cruz, Argentina, and Quebrada Honda, Bolivia, are intermediate in the three metrics between Centenario and La Venta. The tropical Pleistocene fauna of Barro do Antoniao, Brazil, is the ecologically richest and most diverse and disparate fauna in our analysis, whereas three modern faunas from Colombia and Ecuador generally resemble Centenario but are slightly more disparate (and notably less disparate than pre-GABI South American faunas). Prior to the GABI, South American herbivore communities were more ecologically disparate than those of Central America. Ecological disparity increased after the GABI but diminished greatly in both richness and disparity following Pleistocene megafaunal extinctions.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**AN UNUSUAL MIXTURE OF ONTOGENETIC STAGES OF DIPLODOCID SAUROPODS IN THE MYGATT-MOORE QUARRY ASSEMBLAGE (MORRISON FORMATION)**

McHugh, Julia

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Sauropod dinosaurs are common in the Upper Jurassic Morrison Formation of western North America. Fossil sauropods can be recovered as isolated remains or as several individuals in a single deposit. Multi-taxic bone beds often preserve mixed assemblages that include sauropods, with single stages of juveniles and adults occasionally preserved together. However, evidence from trackways indicates age segregation in herds of large-bodied sauropods like diplodocids. However, the presence of juveniles and adults in assemblages indicates that these herds were not geographically segregated, but instead occupied the same regions. What is unusual in the fossil record is the accumulation of multiple sizes of juveniles alongside subadults and adults in the same deposit. The occurrence of multiple sizes of juveniles has only previously been reported for the Carnegie Quarry (CQ) in eastern Utah, a high energy flood deposit that likely accumulated skeletons from a wide geographic area during the formation of the site. Here, I report on the presence of at least four ontogenetic stages at the Mygatt-Moore Quarry (MMQ) in western Colorado (Morrison Formation, Brushy Basin Member). Like CQ, the MMQ is a multi-taxic bonebed with a long history of collection. However, the MMQ represents a low-energy deposit of mud and siltstone units and is interpreted as an attritional overbank fluvial deposit impacting a relatively small geographic area. Interpreted as an autochthonous assemblage, taxa from the MMQ were likely living in the immediate area rather than individuals washed in from a wider area. Sauropod taxa identified at the MMQ include the macronarian *Camarasaurus* cf. *lentus* and *Apatosaurus* cf. *louisae*, with abundant additional diplodocid and sauropod material that is not diagnostic at the genus level. Of the two identified genera, both include juvenile and adult skeletal elements. However, *Apatosaurus* is, by far, the more common taxon in the fossil assemblage, with an estimated 257 identified elements in comparison to the only 31 identified *Camarasaurus* elements. Among the *Apatosaurus* material are several femora belonging to adults, sub-adults, one very large adult, and two sizes of juveniles. They range in proximal-distal length from 52.5-187.6 cm. Here, their morphologies and ontogenetic statuses are described, as well as the implications of the local community composition for age groups of sauropod dinosaurs in the Upper Morrison of western Colorado.

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Technical Session 4: Dinosaur Soft Tissues (Wednesday, October 18, 2023, 1:45 PM)

**INSIGHTS AND LIMITATIONS IN RECONSTRUCTING THE MUSCULATURE AND SKELETAL ARRANGEMENT OF THE FOOT IN TYRANNOSAURIDS AND OTHER NON-AVIAN THEROPOD DINOSAURS**

McIntosh, Annie[1], Sullivan, Corwin[1], Acorn, John[2], Currie, Philip J.[1]

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Reconstructions of the skeleton and musculature in fossil taxa depend on the ability to identify tendinous muscle insertions and ligamentous bone-to-bone contacts on the fossilized bones. However, researchers have not agreed on the identifications of various rugose marks on the bones of the foot in tyrannosaurids and other non-avian theropods, resulting in inconsistent reconstructions of the foot. At some point during the evolution of birds, the first digit (hallux) migrated distally along the second metatarsal from the ankle and became reversed to oppose the other digits. Additionally, M. gastrocnemius inserts onto the calcaneum in crocodilians and other tetrapods, but onto the tarsometatarsus in modern birds, indicating a distal migration of that insertion. Ligaments and tendons are structurally similar and studies have found it difficult to accurately identify and distinguish between osteological correlates of these soft tissue insertions. Therefore, any rugose marks present on the bones of the foot in fossil taxa could represent either muscle attachments or contacts with other bones. Additionally, clear osteological correlates are not always evident in fossil taxa, and undistorted, articulated specimens are relatively scarce. Although reconstructions remain somewhat speculative and should be made cautiously, assumptions can be made based on the skeletal morphology and musculature of modern birds. The morphology of the metatarsals is fairly consistent across Late Cretaceous North American tyrannosaurids, which have two posterior-facing rugose patches on the second metatarsal and one on the fourth metatarsal. Based on the relative positions of the insertion of M. gastrocnemius and the contact of the hallux to the tarsometatarsus in modern birds, it is likely that the rugose patch on the fourth metatarsal and the proximal patch on the second metatarsal represent the insertions of M. gastrocnemius, whereas the distal patch on the second metatarsal represents the contact with the first metatarsal. This indicates that the hallux was distally positioned on the second metatarsal in tyrannosaurids and was to some degree reversed to oppose the other digits, similar to the conditions seen in modern birds. The metatarsals of dromaeosaurids and troodontids, however, are relatively smooth and lack distinct rugose patches like those found in tyrannosaurids, and more research is needed to more accurately reconstruct their morphology.

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Colbert Poster Prize Session

**WHAT IS THE ONTOGENETIC AGE OF EARLY DINOSAURS AND THEIR CLOSE RELATIVES? A SURVEY OF ONTOGENETIC AGES THROUGH HISTOLOGICAL DATA**

McKinney, Isaiah T.[1], Griffin, Christopher[2], Nesbitt, Sterling J.[1]

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Reptiles display a variety of life history strategies that combine various durations and rates of growth. Understanding these different life history strategies is essential to master fitness-concepts and their evolution. Among reptiles, Jurassic and Cretaceous dinosaurs have been shown to reach incredible sizes through relatively fast growth over decadal to multidecadal temporal scales. However, the range of growth strategies employed by the earliest dinosaurs in the Triassic to Early Jurassic are poorly constrained, limiting our ability to place these growth strategies into a broader comparative context of dinosaurian evolution. Here, we compiled a database estimating the lifespan of early dinosaurs and their

closest relatives (avemetatarsalians), which allowed us to partially reconstruct their growth strategies. We gathered our data through histological sections of limb bones and body-size data for 30 dinosaur species and their closest relatives, some with multiple individuals, to contextualize their ontogenetic age at death. We counted lines of arrested growth (LAGs) and other growth marks within the cortex of long bones to estimate a minimum age of each individual. Additionally, we recorded body-size information for either the individual that was sectioned or a more general body-size for the species, depending on available data. Some early avemetatarsalians did not possess LAGs and grew rapidly. On average, early dinosaurs had an average LAG count of ~3. In contrast, non-dinosaurian avemetatarsalians (aphanosaurs, silesaurids) had varying LAG counts from 0 to 3 with an average number closer to 3. Sauropodomorphs (ranging from 0-24, including *Plateosaurus* and *Massospondylus*) and theropods (ranging from 0-6, including *Tawa* and *Herrerasaurus*) from the Late Triassic and Early Jurassic had average LAG counts of ~4 and ~3.5 respectively. Early diverging ornithischians (ranging from 0-6) have an average LAG count of ~3. Preliminarily, there appears to be a correlation between the larger body-sizes and the number of LAGs. From our results, early dinosaurs have similar numbers of LAGs as their closest relatives, especially within the smaller and earliest members of Dinosauria. Further analyses examining the tissues spanning these LAGs may help us better consider the rate of growth and other life history strategies of the earliest dinosaurs.

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**STOP AND TURN BEHAVIOR OF THEROPODS INDICATED BY TRACKWAYS AT THE CARRERAS PAMPA TRACKSITE**

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The Carreras Pampa tracksite in Torotoro National Park (Bolivia) preserves a large number of dinosaur trackways. These trackways consist of tracks that are preserved as concave epireliefs on the exposed surface of an ooid, ostracod-rich arenite, stratigraphically within the middle member of the El Molino Formation (Maastrichtian). In sites 1-3, 34% of trackways have orientations towards azimuth 315°–15° and 29% of trackways have orientations towards azimuth 125°–185°. Based on stride length measurements from site 1, 92% of trackways indicate that the trackmaker was walking. Within individual trackways at the Carreras Pampa tracksite, major changes in direction and speed are rare. However, seven trackways were found that indicated unusual turns, stops, or avoidance behavior by the trackmaker. Turns of more than ~45° are uncommon in theropod trackways across the world. Four theropod trackways with one or more turns ranging from 38°–52° were found at the tracksite. Two trackways indicated the trackmaker was walking, stopped, and then began moving again. In both trackways, the tracks at the stopping point are placed near each other, with one slightly ahead of the other. These stops are also associated with reductions in stride length leading up to the stopping point, indicating a reduction in speed before stopping. Finally, a trackway with a sudden change in direction was found that we interpret as a dinosaur trying to avoid some unknown factor or obstacle. This trackway makes an abrupt move to the right, proceeds for two paces, and then makes a gradual return to its original orientation of movement. The estimated height at hip of trackmakers range from 70–130 cm and all were walking. These trackways combined with others at the tracksite, including trackways with associated tail traces and trackways of swim traces, show that the Carreras Pampa tracksite records a rich record of diverse dinosaur behaviors.

**Funding Sources** Geoscience Research Institute Grant GRI-22-2

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Technical Session 10: Euarchontoglires & Xenarthra (Friday, October 20, 2023, 8:00 AM)

**NEW FOSSIL APE SPECIMENS FROM RUSINGA ISLAND, KENYA, AND THEIR IMPLICATIONS FOR THE EVOLUTION OF HOMINOIDEA**

McNulty, Kieran P.[1], Jansma, Rutger[2], Imfeld, Tyler[3], Lehmann, Thomas[4], Michel, Lauren[5], Muteti, Samuel[6], Peppe, Daniel J.[7]

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Human Evolution and Social Change, Arizona State University, Tempe, Arizona, United States, [3]Biology, Regis University, Denver, Colorado, United States, [4]Paleomammalogy, Senckenberg Research Institute, Frankfurt, Germany, [5]Earth Sciences, Tennessee Tech University, Cookeville, Tennessee, United States, [6]Paleontology, National Museums of Kenya, Nairobi, Kenya, [7]Geosciences, Baylor University, Waco, Texas, United States

Fossil ape specimens from Rusinga Island, Kenya, provide some of the best evidence of the early evolution of hominoids and of the anatomic and taxonomic diversity present in the clade during the Early Miocene of eastern Africa. Here we present new specimens from Rusinga's Hiwegi Formation that provide important new details about the paleobiology and systematics of these early apes. One specimen, a partial cranium of a male *Ekembo heseloni*, reveals that earlier cranial reconstructions of the species were inaccurate and, in comparison with the well-known female cranium discovered by Mary Leakey, that the pattern of cranial dimorphism in *Ekembo* was more like that of great apes than previously anticipated. A second specimen, which includes cranial, dental, and postcranial elements, represents a new taxon of ape and helps disentangle problematic taxonomic distributions of the smaller catarrhines on Rusinga and neighboring Mfangano Island. A new phylogenetic analysis of Catarrhinini further clarifies the relevance of Rusinga's apes in understanding hominoid evolution, with a well-supported Dendropithecidae positioned among stem hominoids instead of stem catarrhines. Finally, reconstructions of cranial shape at phylogenetic nodes based on geometric morphometric data position *Ekembo* near the last common ancestors of crown hominoids and crown hominids, well within the shape domain of Hominoidea.

**Funding Sources** National Science Foundation, Leakey Foundation

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Technical Session 12: Methods & Paleohistology (Friday, October 20, 2023, 8:00 AM)

**RANCHO LA BREA IS THE PITS: A HIGH-RESOLUTION CHRONOLOGY OF MEGAFAUNAL ENTRAPMENT ACROSS THE LAST 49,000 YEARS**

Meachen, Julie[1], Binder, Wendy[2], Campbell, Sean[3], Cohen, Josh[4], DeSantis, Larisa[5], Dunn, Regan[3], Lindsey, Emily[3], Miller, Joshua H.[6], O'Keefe, F. R.[7], Southon, John[8]

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The excellent preservation of thousands of bones found in the Rancho La Brea (RLB) tar pits provides unique opportunities to evaluate mammal communities during the late Pleistocene. Unfortunately, limitations in understanding of the age structure of the pits complicates paleoecological assessments of this important resource. Previous work established rough mean ages for individual pits, and past studies have treated each pit as a single slice of time. However, this approach assumes each pit represents a constrained period of seep activity. Over the last four years the SABER consortium has intensively dated five deposits (pits 10, 61/67, 3, 13, and 91), obtaining over 400 radiocarbon dates on mammal elements. Combined with previously published dates ($n_{total}$ = 643), these data provide unprecedented opportunities to characterize entrapment histories. We reconstructed the spatial and temporal structure of fossils within each pit using specimen positional data (X, Y, and Z coordinates) and individual calibrated radiocarbon dates. Our results show that while pits can include specimens across $10^3$ – $10^4$ years, the bulk of specimens come from specific and non-overlapping intervals (medians and interquartile ranges yrs BP: Pit 10: 6,315 [6,261, 6,495], Pit 61/67: 13,759 [13,300, 14,241], Pit 3: 17,293 [15,796, 18,174], Pit 13: 19,686 [19,293, 19,877], and Pit 91: 32,472 [31,412, 40,594]). We also found that ages of fossils were largely homogenized across pit depths. This most likely resulted from post-depositional mixing in the semi-plastic, asphaltic matrix of the pits. Pit 3 represents an exception, where depth within the pit significantly correlated with age (older ages towards the bottom). Some age-structure is also recovered in Pit 91, in which two clusters of fossils, one circa 40 ka and one circa 28 ka, are in reverse stratigraphic order and spatially separated by only a few meters. Combined with age data, the 3D pit reconstruction revealed a cut-and-fill structure where a stream incised the older strata and redeposited younger material in the channel fill, a process that occurred within 12,000

years. Our study demonstrates the importance of radiocarbon dates for interpreting entrapment histories at RLB, and while some pits may include specimens from across tens of thousands of years, mammal entrapment histories in these pits are largely distinct, offering opportunities to evaluate different periods of RLB history during the late Pleistocene and Holocene.

**Funding Sources** NSF EAR/SGP grant to JM, WB, LD, EL, FRO, and JS

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

### PATTERNS OF LATITUDINAL DISTRIBUTION OF CETACEA AS OBSERVED BETWEEN ANCIENT AND MODERN TAXA

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Modern cetaceans are often thought of as globally distributed. While it is true that cetaceans can be found all across most of the world's oceans there is by no means a uniform geographic distribution of the group. The greatest abundance of cetacean taxa in today's world is concentrated in temperate latitudes, a trend that is notable considering the evolutionary history of the group. The earliest archaeocetes are understood to have evolved, during the early Eocene, at near-equatorial latitudes, specifically on the Indian subcontinent prior to its collision with the Eurasian plate. Archaeocetes then rapidly spread along a primarily longitudinal gradient. Using records from the Paleobiology Database (PBDB) and the Ocean Biodiversity Information System (OBIS) we examined the latitudinal distribution of Cetacea through the Cenozoic. From these data we modeled the taxonomic diversity for Cetacea along a latitudinal distribution. Our results indicate that cetacean diversity is concentrated mostly at lower latitudes with only moderate poleward movement throughout the Eocene before the establishment of more temperate latitudinal bins in both the northern and southern hemispheres during the Oligocene. This pattern of bimodal distribution of taxa remains remarkably stable throughout the Miocene diversity peak and through the Pliocene as we begin to see a reduction in taxonomic diversity in the group. As we reach the Quaternary, a sudden emergence of cetaceans in subarctic and polar latitudes for the first time in the history of the group is apparent though with comparatively low taxonomic diversity. Presence of Cetacea at subarctic and polar latitudes is a phenomenon evident in both hemispheres and is a pattern which is maintained today. Despite obvious latitudinal expansion over the Cenozoic, the greatest taxonomic diversity of cetaceans has been maintained in a temperate, latitudinal band to that which appeared in the Oligocene. The modern distribution of Cetacea is thus the most globally expansive in the group's history despite a lower taxonomic diversity than is seen in the Miocene. The bimodal distribution of cetacean taxa at temperate latitudes is maintained into the modern. Given that this bimodal distribution emerges mostly clearly through the Oligocene we can note that the pattern correlates in time with the divergence of the Neoceti, a major event in the evolutionary history of Cetacea.

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Technical Session 2: Early Mammals & Carnivora (Wednesday, October 18, 2023, 8:00 AM)

### MIDDLE PALEOCENE (LATE TORREJONIAN) MULTITUBERCULATE MAMMALS FROM THE MEDICINE ROCKS AREA, EKALAKA, MONTANA

Meltesen, Kirsten M.[1], Krause, David W.[2], Cheong, Hee Jun[3], Sprain, Courtney[3], Wilson Mantilla, Gregory[1]

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Multituberculate mammals reached peak generic richness during the middle Paleocene, during the Torrejonian North American Land Mammal Age. Yet, their relative abundance within mammalian faunas declined from the Puercan into the Torrejonian and Tiffanian, coincident with increases in the abundances of archaic ungulates and plesiadapiform primates. Increased sampling of Torrejonian and Tiffanian mammal microfossil localities will help us better understand the nature of these diversity trends and begin to unravel the processes that underpin them. In Montana, middle Torrejonian and early Tiffanian multituberculates are relatively well sampled (e.g., Gidley Quarry, Douglass Quarry, Scarritt Quarry), but the late Torrejonian zone is not as well known. Here, we

describe a putative late Torrejonian multituberculate fauna from the Medicine Rocks Site 1 and Mehling Site localities in the Medicine Rocks area north of Ekalaka, Carter County, Montana (Fort Union Formation, Powder River Basin) based on a collection of at least 92 isolated premolar and molar specimens housed at the Carter County Museum. A handful of multituberculates have previously been described from these sites: *Baiotomeus lamberti, Mesodma pygmaea, Neoplagiaulax "nelsoni," Parectypodus sylviae*, *Ptilodus wyomingensis,* and *Ptilodus* sp. T. This work expands the known fauna to include *Mimetodon*, several species of *Ectypodus*, and additional species of *Parectypodus*, *Neoplagiaulax,* and *Baiotomeus*, including *B. rhothonion* (the first known occurrence of this taxon outside of its type locality in Alberta). Overall, the multituberculate component of the Medicine Rocks local fauna appears to share the greatest taxonomic affinity with penecontemporaneous localities from the northern Western Interior (e.g., Montana, Alberta). In addition to working with existing museum collections, we continue to sample at Medicine Rocks Site 1 and the Mehling Site through both surface and bulk sediment collection. We expect screenwashing will further increase the multituberculate samples known from these sites. As part of this ongoing work, we are conducting a magnetostratigraphic study to better constrain the age of the Medicine Rocks local fauna, as previous estimates were based primarily on the plesidapiform primates described from these sites.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**AN ARTICULATED POLYCOTYLID POSTCRANIUM (*DOLICHORHYNCHOPS* SP.) FROM THE BEARPAW SHALE (UPPER CRETACEOUS) OF MONTANA**

Metz, Eric T.[1], Druckenmiller, Patrick S.[2]

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Polycotylidae is a diverse clade of short-necked plesiosaurians recovered worldwide from Cretaceous marine deposits. *Dolichorhynchops* is the most speciose polycotylid, containing four species: *D. bonneri*, *D. osborni*, *D. tropicensis* and *D. herschelensis*. Phylogenetic analyses of Polycotylidae have questioned the monophyly of *Dolichorhynchops*, and similarly the relationships of its nominal species to other genera (e.g., *Mauriciosaurus*, *Trinacromerum* and *Georgiasaurus*) are labile. *D. herschelensis*, at less than 3 meters in length, is the smallest species of *Dolichorhynchop*s and is the only polycotylid known from the Bearpaw Shale, which records the last major marine transgressive event of the Western Interior Seaway. The holotype, and only published specimen of *D. herschelensis* (Royal Saskatchewan Museum P.2310.1), is a disarticulated partial skeleton preserving the skull, girdles, some vertebrae, and a few distal phalanges. Notably the holotype lacks a complete vertebral count and any limb material. Museum of the Rockies (MOR) 6689, collected from the Bearpaw Shale of Montana in 2010, lacks a skull but preserves a partial articulated postcranial skeleton of a small, ontogenetically mature polycotylid. MOR 6689 includes three sections of articulated vertebrae: two sets of articulated cervical vertebrae and a complete dorsal, sacral, and caudal series. The specimen has a minimum of 34 presacral vertebrae, as well as 3 sacrals and 23 caudals. All vertebrae have fully fused neural spines, the dorsal neural spines are 2.5 times as tall as high, while the anterior caudals are 3 times as tall as high. Additional material includes a distal humerus with an articulated radius and ulna, a partial pectoral girdle, and a nearly complete left hindlimb. The femoral trochanter is rectangular in proximal view, the anterior margin is slightly concave and articulates to two supernumerary ossifications. Digit I on the hindlimb is incomplete, however a phalangeal count of the other digits is II-9, III-11, IV-10, V-9. We tentatively refer MOR 6689 to *D. herschelensis* on the basis of its small adult size and geologic provenance. MOR 6689 contributes potentially new morphological data about *D. herschelensis,* currently recognized as the youngest occurrence of a polycotylid in the Western Interior Seaway.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**LOWER ACTINOPTERYGIAN FISHES FROM THE UPPER PENNSYLVANIAN HAMILTON QUARRY, A KONSERVAT-LAGERSTÄTTE IN SOUTHEASTERN KANSAS, U.S.A.**

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The Upper Pennsylvanian (Virgilian) Hamilton Quarry in southeastern Kansas (U.S.A.) has been categorized as a Konservat-Lagerstätte because of the abundance and exceptional preservation of aquatic and terrestrial vertebrates, invertebrates, and plants recovered from this site. Lower actinopterygian fishes are among the Hamilton Quarry fauna and while they are not the most numerous or diverse vertebrates from this locality, they are represented by well-preserved articulated to partially articulated specimens. The quality of the preservation makes the actinopterygians from this site particularly important. Currently, there is no consensus on the relationships of lower actinopterygians, a problem that is partially attributed to need for detailed descriptions and redescriptions of taxa as well as deeper investigations into morphological characters that are included in phylogenetic analyses. Hamilton Quarry actinopterygians have been previously investigated in a dissertation, but taxa have not yet been formally described. Some of the Hamilton Quarry fishes, including two acid-prepared specimens that preserve three-dimensional views of the skull bones, scales, and vertebral elements, were designated in this unpublished dissertation as belonging to a new genus and species. These specimens are reexamined and presented here. This includes a reinvestigation of the dermal bones of the skull, deeper bones of the palate and hyoid arch, the dentition, vertebral elements, and features of the dorsal and caudal fins. Additionally, a previously undescribed actinopterygian specimen from the Hamilton Quarry is presented and compared to the previously proposed new genus and species from this locality. This specimen, also acid-prepared and showing three-dimensional views of superficial and deep structures, preserves information on the dermal skull bones in the circumorbital series, cheek, operculogular apparatus, and shoulder girdle, as well as details regarding dentition, the parasphenoid, coronoids, vertebral elements, and fin supports. The lower actinopterygians from the Hamilton Quarry are compared to each other as well as other Carboniferous fishes.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**BIOGEOGRAPHIC REORGANIZATION OF LATE PLEISTOCENE-HOLOCENE CARIBOU (*RANGIFER TARANDUS*)**

Miller, Joshua H.[1], McDonald, H. Gregory[2], Gaetano, Madison[1]

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How will the geographic ranges of species respond to modern climate change and increasing anthropogenic perturbations? Caribou (*Rangifer tarandus*) are a highly mobile, keystone species found across the Holarctic. Yet in North America, many herds are threatened or already extinct due to combinations of climate change, logging (habitat removal), and over-hunting. These losses have resulted in a northward shift and reduction in the geographic range of North American caribou. To contextualize these recent challenges, we use the fossil record to quantify how the geographic range of North American caribou changed across the late Pleistocene and Holocene (last ~30,000 years). To do this, we amassed data from the literature on North American caribou fossils that were directly radiocarbon dated and remains found in association with other dated fossils. We also logged each specimen's spatial location (longitude and latitude). We paid particular attention to shifts in the northern and southern boundaries of the geographic range, along with latitudinal breadth (the difference between the northern and southern extent of caribou). We found that past shifts in the geographic range of caribou were coincident with changes in climate. For example, as climate cooled into the Last Glacial Maximum, caribou in Alaska and Yukon retreated southward before expanding northward during subsequent warming (Bølling-Allerød) at the end of the Pleistocene. The southern extent of caribou (e.g., Alabama, Georgia) was broadly stable during the late Pleistocene. However, few directly dated specimens are available from this region, complicating our ability to evaluate changes through time. During the Holocene, we find dramatic northward shifts of both the southern and northern extents of caribou. This includes a middle Holocene expansion of caribou into the High Arctic of Canada, including Ellesmere Island. Because the northern extent of caribou expanded faster than its southern boundary, the overall latitudinal extent of caribou steadily expanded across most of the last ~10,000 years. In contrast to this historical context, extirpations of caribou herds starting in the early 1900s in Maine, Michigan, British Columbia, and recently in Idaho (last individual removed in 2019), is reversing long-standing patterns of caribou range dynamics in North America. These results highlight the capacity of anthropogenic perturbations to alter millennial-scale patterns of mammalian biogeography.

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Colbert Poster Prize Session

**NEW PALEOCENE METATHERIAN FROM THE TIFFANIAN OF BIG BEND NATIONAL PARK, TEXAS AND ITS RELATIONSHIP TO OTHER LATE CRETACEOUS AND EARLY PALEOGENE METATHERIANS**

Miller, Kristen, Beard, K. Christopher

Ecology and Evolutionary Biology, University of Kansas, Lawrence, Kansas, United States

The Black Peaks Formation (BPF) located in Big Bend National Park, Texas samples the southern-most fossil vertebrate localities dating to the late Paleocene (~60-56 Ma) of North America. Two main localities (Tiffanian NALMA) within the Black Peaks Formation have yielded a diversity of fossil mammals including multituberculates, plesiadapiforms, condylarths, and insectivores. Here, we present a new species of metatherian from the Tiffanian of Big Bend National Park and place it in a phylogenetic context. During the Late Cretaceous, metatherian diversity was at an all-time high and vastly outpaced eutherian mammals in terms of taxonomic, morphological, and geographic diversity. However, following the Cretaceous-Paleogene (KPg) extinction, North American metatherians saw a decline in diversity as eutherian mammals radiated and diversified. Two main groups of metatherians survived the mass extinction at the KPg boundary in North America, the peradectids and the herpetotheriids. While one herpetotheriid taxon is known from the Paleocene, the peradectids were the dominant Paleocene marsupials. During the Paleocene, metatherian body size was exceptionally small and did not begin to increase until the appearance of *Mimoperadectes* in the fossil record of the early Eocene. The new taxon from the Black Peaks Formation is the largest species of metatherian yet discovered from the Paleocene (comparable in size to *Mimoperadectes*), raising questions regarding its phylogenetic affinities. Is the BPF metatherian a holdover from the larger Cretaceous metatherian radiation, or an early member of the Wasatchian *Mimoperadectes* clade? A phylogenetic analysis of 164 characters coded for 49 taxa was performed using TNT to answer this question and provide insight into the biogeography of North American metatherians during the early Paleogene. Initial results ally the BPF metatherian with Paleocene and Eocene Peradectidae, suggesting that a large-bodied clade of peradectids originated at southern latitudes during the mid-late Paleocene and dispersed northward during the Wasatchian in association with PETM warming.

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Virtual Posters

**RHIZOETCHING TRACE FOSSILS ON *TRICERATOPS* BONES FROM THE LATEST CRETACEOUS FRENCHMAN FORMATION, SASKATCHEWAN, CANADA; INSIGHT INTO RECONSTRUCTING TAPHONOMIC PATHWAYS OF VERTEBRATES IN PALEOSOLS**

Milligan, Jack R.[1], Bamforth, Emily[2], Mangano, Maria G.[1], Buatois, Luis A.[1]

[1]Department of Geological Sciences, University of Saskatchewan, Saskatoon, Saskatchewan, Canada, [2]Philip J. Currie Dinosaur Museum, Wembley, Alberta, Canada

Bioerosion trace fossils are biogenic structures that record evidence of behavior in hard substrates, including rocks, wood, shells, and bones. While bioerosion trace fossils on vertebrate bones by invertebrate and vertebrate trace makers have been well documented globally throughout the Mesozoic and Cenozoic (251.90 - 66.0 ma, 66.0- 0.0 ma), studies on bioerosion structures created by ancient plants are less common. Rhizoetchings are structures resulting from the chemical activity of roots on the surface of bone, which fall into the ethological category Corrosichnia. Herein, we document several bones from a subadult *Triceratops* individual, RSKM P3339.1 from the Maastrichtian Frenchman Formation in southwestern Saskatchewan, Canada, which features several bioerosion trace fossils. During preparation of the *Triceratops* material, the presence of plant material preserved as a thin, long black carbonaceous film was noted, as well as the three-dimensional preservation of roots close to the bone. Following preparation of the plant material, shallow grooves on the cortical surface of the bone became apparent. The structures are commonly unbranching, although branching may be present locally. The bioerosion trace fossils were identified as rhizoetchings created by ancient plant root structures. The quarry succession consists of a blocky white to pink plant-rich mudstone, with a dense system of fossil root structures surrounding the *Triceratops* material. The depositional environment is interpreted as a heavily vegetated floodplain paleosol. It is likely that, some time after the *Triceratops* was buried, a plant community became established to take advantage of the bones for nutrients. Ancient plant bioerosion trace fossils on bones are rarely studied and poorly understood in the Late Cretaceous of Canada. The ongoing study of trace fossils on *Triceratops* specimens from Saskatchewan will contribute to our understanding of the taphonomic processes that affect Cretaceous vertebrate deposits and will elucidate the previously unappreciated role ancient plants played in the preservation of dinosaur material.

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Technical Session 18: Synapsids (Saturday, October 21, 2023, 8:00 AM)

**PRELIMINARY REPORT OF TRITYLODONTID BONEBEDS IN THE LOWER JURASSIC KAYENTA-NAVAJO TRANSITION (GLEN CANYON GROUP) AT GLEN CANYON NATIONAL RECREATION AREA, UTAH**

Milner, Andrew[1], Marsh, Adam D.[2], Sues, Hans-Dieter[3], Buchwitz, Jaleesa C.[1], Carter, Hunter A.[1], Santucci, Vincent[4]

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The Lake Powell shorelines in Glen Canyon National Recreation Area expose Permian through Jurassic redbeds rich in fossil resources, many of which have been the focus of inventories spanning more than three decades. Lake level fluctuations during a given year, many fossil sites are continuously being documented due to the significant weathering on the Colorado Plateau. In March 2023, NPS paleontological resource inventory and monitoring led to the discovery of a bonebed containing disarticulated but associated tritylodontid cynodonts in a basal interdunal lacustrine unit in the Navajo Sandstone (Lower Jurassic). The bonebed has been submerged since 1965 so most of the exposed elements are preserved as natural molds in friable sandstone, the bone having been dissolved or broken apart by shoreline and submerged conditions. An emergency recovery mission in April 2023 resulted in the discovery of articulated skeletons at the first site and a second, older tritylodontid bonebed nearby.

The Navajo Sandstone is known for its ichnofauna, famously including tracks of saurischian and ornithischian dinosaurs, crocodyliforms, and mammaliamorphs in the form of *Brasilichnium*. Unlike the underlying Kayenta Formation, body fossils from these taxa are extremely rare in the Navajo Sandstone. Only two named taxa occur in the latter, each known from a single specimen: the sauropodomorph *Seitaad ruessi* from SE Utah and the coelophysoid *Segisaurus halli* from northern Arizona. The only other body fossils from the Navajo are fragmentary semionotiform fishes from southern Utah, and two indeterminate partial sauropodomorphs, three fragmentary protosuchid crocodyliforms, and a single postcranial skeleton of a tritylodontid, all from northern Arizona. The Arizona tritylodontid specimen was tentatively referred to *Kayentatherium*, also present in the underlying Kayenta Formation, but without preserving diagnostic dental features it may also belong to *Dinnebitodon* or an unknown taxon.

Specimen preparation of the GLCA material is ongoing, but preliminary observations suggest these fossils closely resemble *Kayentatherium*. Although not the first reported occurrence of tritylodontids in the Navajo Sandstone, the number of preserved disarticulated elements and articulated skeletons in these bonebeds may help determine the taxonomic identity of tritylodontids in the Navajo Sandstone, further documenting the evolution of these mammaliamorphs in the Lower Jurassic of the American Southwest.

**Funding Sources** National Park Service

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Technical Session 13: Fishes - Actinopterygians (Friday, October 20, 2023, 1:45 PM)

**COMPARATIVE PHYLOGENETICS OF EARLY ACTINOPTERYGIAN FISHES**

Miyashita, Tetsuto

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One out of every two living vertebrate species is an actinopterygian (ray-finned fish). Despite this massive success, interrelationships of early actinopterygians remain unstable and controversial. Actinopterygians from the Devonian and Carboniferous times may fall outside or sit within the crown group, and may form their own clusters or nest with the living lineages. In what combination and what context do the factors of phylogenetic uncertainty (e.g., homoplasies, missing data, insufficient sampling, differential rates, conflicting signals) contribute to this problem?

To identify the causes of instability for the actinopterygian crown, I compared phylogenetic datasets that generated radically different trees of early actinopterygians. I found that relative branch lengths vary predictably over the trees regardless of phylogenetic hypotheses. Unevenness of branch length distribution is mainly driven by the long living branches such as *Acipenser* and *Polypterus*. However, the core group of early actinopterygians (conventionally referred to as 'palaeoniscoids') tends to have relatively longer terminal branches, and their internal nodes account for a larger proportion of inferred synapomorphies in the dataset, in the earlier analyses. In the recent analyses, increased character and taxon sampling contributed disproportionately to non-palaeoniscoid parts of the tree. Next, comparison of phylogenetic and phenotypic distances reveals that these recently added character variations drive overall homoplasies in the datasets, perhaps to the point of diminishing returns. This is mainly because the positive relationship between phylogenetic and phenotypic distances weakens with increasing sampling. However, state-step curves show that actinopterygians continue to add novel characters toward the teleost crown. A distinct uptick of novel state acquisition is detected in the post-Devonian radiation, implying an ecological release. Thus, the character space is never entirely exhausted in any actinopterygian dataset I examined. These results suggest that: 1) increased sampling has outpaced improvement in data quality; and 2) sampling focused on a particular type of characters and a particular part of the tree can recover robust signals. Indeed, I show that the endocranial characters overall have lower homoplasies and evolve novel states more steadily than dermal characters. Cultivating such characters may be the key to phylogenetic resolution of early actinopterygians.

**Funding Sources** Canadian Museum of Nature National Science and Engineering Research Council, Canada

Virtual Posters

**NEW MATERIAL OF A GROUND SLOTH *NOTHROTHERIOPS* SP. (MAMMALIA: XENARTHRA) FROM THE EL CEDAZO LOCAL FAUNA, AGUASCALIENTES, MÉXICO**

Montellano Ballesteros, Marisol[1], Vazquez, Miguel[2], Barrón-Ortiz, Christina[3], Ramos-Heredia, Jesús E.[4], Ramos-Heredia, Jesús A.[5]

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In the 70`s Mooser and Dalquest described the El Cedazo local fauna recovered from the surroundings of the city of Aguascalientes, which they assigned to an Illinoian age. Among the described mammalian taxa was a small ground sloth identified as *Nothrotheriops* cf. *N. shastensis*, represented by one tooth and some postcranial material (two humeri, half of a femur, a vertebra, and an ungual phalanx). Recently, an almost complete lower jaw of *Nothrotheriops* was collected by one of the authors (MV) in one of the ravines that yielded the El Cedazo local fauna. The lower jaw preserves three molariforms in each side, unfortunately the mandibular spout is missing. The maximum length of the lower jaw is 205.72 mm, the alveolar length of right side is 48.05mm, the left side is 46.76mm. Comparison of this new specimen from El Cedazo with the Rancholabrean *N. shastensis* and Irvingtonian *N. texanus* indicates some differences and similarities. The tooth row is smaller than juvenile sloths of *N. shastensis* from Rancho La Brea and San Josecito Cave, but it is similar to *N. texanus* from Leisey Shell Pit 1A. The ratio of total alveolar length of the mandible against depth of the mandible at the third molariform falls closer to *N. texanus* than to *N. shastensis.* Unlike, both species of *Nothrotheriops*, the ascending ramus is elongated posteriorly, it is half of the total length of the lower jaw (without mandibular spout), and it forms an obtuse angle of 136° with respect to the alveolar tooth row. It is possible that these differences are ontogenetic in nature and further comparisons with juvenile and adult *N. shastensis* and *N. texanus* are required to evaluate this possibility. *Nothrotheriops* first appears in North America in the Irvingtonian, and two species are recognized: the Irvingtonian *N. texanus* and Rancholabrean *N. shastensis*. It has been suggested that both taxa represent an evolving lineage, so to demarcate the boundary between them is difficult.

The specific identification is unknown, but a feeding habit is possible to suggest. The second and third molariforms of both sides of the mandible are sufficiently well preserved for mesowear analysis. Based on the mean mesowear angle (108.8°), this particular individual is inferred to be a mixed feeder. These results are in contrast to previous studies on the feeding habits of *Nothrotheriops*, particularly *N. shastensis* from southwestern United States, which is suggested to be a browser of xeric shrubs, based on dung.

**Funding Sources** We acknowledge the efforts of the Guardabosques de "Los Cobos" A.C. to protect the natural and paleontological heritage of the surroundings of the city of Aguascalientes

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**EXCEPTIONAL PRESERVATION OF CARTILAGINOUS ELEMENTS IN AN EARLY CAPTORHINID REPTILE AND NEW INSIGHTS INTO EVOLUTION OF THE STERNUM AND COSTAL RESPIRATION**

Mooney, Ethan D.[1], Maho, Tea[1], Bevitt, Joseph[2], Reisz, Robert[1]

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The success of early amniotes in terrestrial environments has been largely attributed to the amniotic egg, but the evolution of costal respiration (rib assisted breathing) and separation of the shoulder girdle from the skull giving rise to the neck are also crucial innovations. Greater respiratory efficiency facilitated by costal respiration in conjunction with greater head mobility via the neck allowed for the adoption of more competitive active feeding strategies in early amniotes. Although there were several modifications to the anterior skeleton and musculature to support the transition from buccal pumping (throat assisted breathing as seen in frogs) and cutaneous respiration (respiration through the skin) in anamniotes to more efficient costal respiration in amniotes, the fossil record of the early Permian when amniotes became well established provides only scant evidence for this evolutionary transformation. Here, we present the first substantiated skeletal evidence for the presence of a ribcage with costal respiration as the main respiratory mechanism in the early amniote *Captorhinus*. Exceptional preservation of this fossil can be attributed to the unique depositional conditions at the Richards Spur locality, in which impregnation of organic material with oil-seep associated hydrocarbons was crucial for the diagenesis of cartilaginous and ossified materials. We have utilized high-resolution micro-computed tomography (mCT) to visualize, for the first time, a cartilaginous reptilian sternum with sternal rib extensions, both epicoracoidal cartilages, and cartilaginous cervical rib extensions within the exceptionally well-preserved articulated shoulder girdle of a subadult skeleton of this reptile. Distally expanded cervical ribs, common among early tetrapods, are articulated with almost equally long cartilaginous extensions, all of which are retained within the space between the scapulacoracoid and likely functioned as physical support and/or attachment for associated musculature. Cartilaginous sternal rib extensions articulated with the well-developed reptilian sternum are also clearly related to the thoracic ribs, able to form the typical amniote rib cage for the lungs and able to facilitate effective costal inspiration. Even though this system has been subsequently modified in later amniotes such as mammals and birds, the underlying rib assisted inhalation is retained as a critical foundational mechanism in amniote respiration.

**Funding Sources** Supported by a Natural Sciences and Engineering Research Council (NSERC) scholarship to T.M., and NSERC grant to R.R.R., and the Jilin University, China.

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Virtual Posters

**SOUTH AFRICA'S EARLIEST GIANT: THE SYSTEMATICS AND PALEOBIOLOGY OF A NEW SAUROPODOMORPH DINOSAUR**

Moopen, Atashni[1], Chapelle, Kimberley (Kimi)[1], Benson, Roger[2], Barrett, Paul[3], Botha, Jennifer[1], Choiniere, Jonah[1]

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The Elliot Formation (EF) of South Africa preserves a diverse archosauromorph assemblage spanning the Late Triassic to Early Jurassic. The most common dinosaurs preserved in the EF are sauropodomorphs, with a variety of taxa showing a range of body sizes and postures. However, the lower EF (lEF), of Norian-Rhaetian age, has fewer well-provenanced, associated or articulated specimens in comparison to the upper Elliot Formation (uEF, Lower Jurassic). Late Triassic non-sauropodan sauropodomorphs are key to understanding the evolution of morphological and biological innovations that appear throughout the clade's history. Here, we discuss the anatomy, paleobiology, and systematics of a new Norian sauropodomorph (BP/1/8469) from the lEF of Qhemegha, Eastern Cape Province, whose remains consist of a well-preserved, associated postcranial skeleton of a large, skeletally mature individual. We used comparative anatomy, quantitative estimates of body mass and posture, osteohistology, and phylogenetic analyses to thoroughly investigate BP/1/8469. This specimen is a 1.8 - 3.1 metric tonne, facultative quadruped. This 'intermediate' posture is uncommon among sauropodomorphs and might reflect a transitional stage of locomotory evolution. Its adult status is based on the presence of an External Fundamental System, and it displayed rapid but interrupted growth, similar to other sauropodiforms. Maximum parsimony analyses recover BP/1/8469 as a late-branching sauropodiform close to sauropod origins, whereas Bayesian inference recovers it in an earlier-branching position near the base of Sauropodiformes. Low support for both hypotheses highlight the need for developing more comprehensive data matrices for understanding sauropodomorph phylogeny, and signals considerable homoplasy in sauropodomorph evolution, perhaps related to the repeated evolution of large body size. BP/1/8469 highlights the morphological and physiological variation that non-sauropodan sauropodomorphs possessed, and suggests high levels of morphological experimentation in early sauropodomorph evolution.

**Funding Sources** GENUS: DSI-NRF CoE in Palaeosciences (GUN No. 132868) and DSI-NRF AOP grants awarded to JNC (GUN No. 118974, 136516).

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

### INVESTIGATING PATTERNS OF NEUROCENTRAL SUTURE FUSION IN THE EARLY-DIVERGING THERIZINOSAURIAN *FALCARIUS UTAHENSIS*

Moore, Adam V.[1], Freimuth, William J.[2], Zanno, Lindsay E.[3]

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Accurately assessing relative maturity in archosaurs is crucial for interpretations of their taxonomy and systematics, evolutionary and ecological patterns, and life history traits. A commonly used metric to assess maturity in extinct archosaurs is the degree of sutural fusion at the neurocentral juncture, which separates the vertebral centrum from the neural arch and progressively closes through ontogeny. Extant archosaurs—crocodilians and birds—exhibit opposing patterns of neurocentral suture closure progression along the axial column through ontogeny (caudal-cranial vs. cranial-caudal, respectively). Extinct archosaur clades exhibit variable or non-analogous progressions of neurocentral suture closure relative to crown clades. As a result, the evolution of these patterns, particularly in non-avian theropod dinosaurs, is poorly understood.

We examined patterns of neurocentral suture closure in *Falcarius utahensis*, an early-diverging therizinosaur preserved in a mass death assemblage at the Lower Cretaceous Crystal Geyser Quarry (CGQ) in Utah, USA. The sample of vertebral centra examined to date (n=140) is dominated by caudals (63% total; 17% proximal; 46% distal) followed by progressively fewer dorsals (20%), cervicals (10%), and sacrals (8%). To track suture status and centrum size, we binned each vertebra to one of four qualitative categories (open, partially open, partially closed, and closed), and measured up to five standardized dimensions to calculate a geometric mean value. Generally, the degree of fusion advances with increases in centrum size; discrepancies likely reflect individual and/or positional variation within a region. No distal caudals, regardless of size, are open (95% closed, 5% partially closed), whereas progressively greater proportions of open sutures are observed in proximal caudals (50%), sacrals (50%), dorsals (79%), and cervicals (86%). These patterns suggest that neurocentral suture closure initiated caudally and progressed cranially along the axial column in *F. utahensis*. However, further sampling of precaudal regions will be required to rule out all alternative interpretations. Although variable suture sequences along the axial column have been reported for other non-avian theropods, we hypothesize that the cranial-caudal sequence (along with other specialized developmental modifications) that typifies extant birds may have evolved further crownward than Maniraptora.

**Funding Sources** This material is based upon work supported by the National Science Foundation award #1925973 to LZ

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Technical Session 1: Sauropod & Ornithischian Dinosaurs (Wednesday, October 18, 2023, 8:00 AM)

### NECKS TO NONE: ALLOMETRIC SCALING OF THE CERVICAL VERTEBRAL SERIES IN SAUROPOD DINOSAURS

Moore, Andrew

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With their long necks and formidable bodies, sauropods are among the most instantly recognizable dinosaurs. Previous research on sauropod neck evolution has suggested that the exceptionally long necks of the largest sauropods resulted primarily from a developmental constraint inherited from their bipedal sauropodomorph ancestors. Under this scenario, positive allometric scaling of the neck evolved early in sauropodomorph history, prior to the evolution of quadrupedality and gigantism, where it provided a novel selective advantage in reaching higher browse; later sauropods were simply developmentally constrained to maintain this relationship. Problematically, previous work has not established where along the sauropodomorph stem this hypothesized regime arose, nor demonstrated statistically that scaling in sauropodomorphs is distinct from other non-avian dinosaurs.

Here, I apply reversible jump Bayesian modeling and phylogenetic analysis of covariance to a dataset of 94 non-avian dinosaurs to agnostically discover and statistically evaluate evolutionarily distinct scaling relationships between neck length and body size (approximated by trunk length). Isometric scaling describes all non-avian dinosaurs with the exception of sauropods, which are characterized by a shift to a strongly positive allometric relationship between neck and trunk lengths (b=1.90, 95% confidence internal: [1.22, 2.58]). Contrary to previous work, the best-fit model places this shift at the origin of Sauropoda, approximately coincident with the evolution of obligate, column-limbed quadrupedality and an increase in the number of cervical vertebrae from 10 to 12. This shift location is favored decisively over alternative scenarios in which allometric scaling evolved earlier, either at the origin of Sauropodomorpha ($\Delta$AIC = 12.72) or in concert with the adoption of a predominantly herbivorous diet ($\Delta$AIC = 9.97), although an increase in intercept is recovered at the latter node. Within Sauropoda, additional shifts to a scaling regime with a larger intercept occurred independently in mamenchisaurids, *Rapetosaurus*, and *Euhelopus*, all of which have 17 or more cervical vertebrae. These results suggest 1) that the adoption of obligate quadrupedality was an important precondition for the evolution of allometric neck scaling, and 2) that the particularly extreme proportions of several sauropod lineages were not a product of constraint but were instead selectively advantageous.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

### MODERN VERTEBRATE TAPHONOMY ON THE PILCOMAYO DISTRIBUTIVE FLUVIAL SYSTEM IN PARAGUAY AS A MODEL FOR THE TERRESTRIAL FOSSIL RECORD

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Deposition in all modern sedimentary basins is dominated by Distributive Fluvial System (DFS) facies and so, by extension, it is hypothesized that the bulk of terrestrial sedimentary rocks were deposited by DFSs. Interpreting terrestrial fossil assemblages in a DFS framework has the potential to unlock new or improved palaeoecological data by providing a model of how paleoenvironments, hence taphonomy and ecology, are expected to vary on a landscape scale. By Walther's Law these secular lateral changes in environment will translate to secular vertical changes in the stratigraphic record. While limited research has been carried out to study DFS paleoecology and taphonomy in the rock record, no modern taphonomic studies of the kind needed to ground-truth deep time interpretations have been undertaken explicitly within a DFS framework. Here we will present preliminary data from such a study located on the Pilcomayo DFS in western Paraguay.

Three localities along an ~400km reach of the Pilcomayo DFS were surveyed on foot for the presence of bones or other material that could contribute to a future fossil assemblage: one more proximal to the DFS apex (although still ~70km from the apex itself); one medial; and one distal, within ~10km of the intersection of the Pilcomayo DFS with the tributary system that drains the basin (the Paraguay River). The environments surveyed in each locality were classified among seven DFS sub-environments to test existing hypotheses of DFS preservation. Only the apex proximal locality preserved an abundant surface bone assemblage, with disarticulated elements of medium to large vertebrates common in the reworked channel belt sediments and an associated skeleton present in an ephemerally active channel. Rare, disarticulated elements were present in the medial and distal localities, but it is hoped that more extensive surveys to be undertaken in the summer of 2023 will increase this sample size and better our understanding of preservation in these locations. Of particular note was the reduced understory vegetation in more proximal environments allowing for less disrupted surface flow on flooding, hence increasing the likelihood/distance of element transport, and the abundance of fallen trees (potentially hundreds of kilometers from their source) in even small active channels creating baffles for sediment accumulation and hence loci of burial.

**Funding Sources** We thank the University of New Mexico Honors College Research Institute for fieldwork support

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Technical Session 20: Marine Mammals & Bats (Saturday, October 21, 2023, 1:45 PM)

### INSIGHTS FROM MICROCT-SCAN OF THE EARLIEST FOSSIL BAT FROM BRAZIL – *MORMOPTERUS* (*NEOMOPS*) *FAUSTOI* (CHIROPTERA: MOLOSSIDAE), AN OLIGOCENE HOLOTYPE LOST IN THE FIRE OF THE MUSEU NACIONAL

Moraes-Neto, Carlos R.[1], Perini, Fernando A.[2], Guedes, Patrícia G.[1], Carvalho, Alberto B.[3], Toledo, Peter M.[4], Arroyo-Cabrales, Joaquín[5], Salles, Leandro d.[1]

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*Mormopterus* (*Neomops*) *faustoi* is the most complete fossil among the few Tertiary bats known from South America. It was recovered from late Oligocene bituminous shales of the Tremembé Formation (São Paulo) and described by Paula Couto in 1956, with a diagnosis exclusively based on dentition. Tragically, the holotype was lost in the 2018 fire that devasted the Museu Nacional's unique collections. Fortunately, the specimen (MN3000-V) was microCT-scanned a few years before the incident, a fact that highlights the importance of those image-generating techniques to preserve anatomical information of rare specimens. Here, the initial outcomes of the reassessment of the anatomy of *M. faustoi* based on those digitalized images is presented. The skull is poorly preserved, being represented by the upper dentition (P4-M3) and the dentaries, with one especially well-preserved, retaining most of the teeth in their alveoli. Exceptional preservation is found in many postcranial bones, including the articular portion of the scapula, humeri, radii, some metacarpal bones, proximal end of the femur, tibia, some tarsal bones (including the calcaneus), clavicle, part of the acetabulum, and some vertebrae. The genus *Mormopterus* has a long and confusing taxonomic history and it has become clear in recent years that it is most likely not monophyletic, with molecular studies separating apart its different lineages. The taxonomic history of *Mormopterus* is also closely related to that of *Tadarida*, another wastebasket taxon. It seems likely that part of the misperception is due to both *Mormopterus* and *Tadarida* including species that display conservative morphologies in regard to molossid bats. The situation is aggravated when fossils are considered, with many extinct species being assigned to either one of these two genera without any sustainable basis of evidence. *M. faustoi* itself was originally described as *Tadarida faustoi* before being reinterpreted as a species of *Mormopterus* by Serge Legendre in the new subgenus, *Neomops*. Thus, this paleontological study uses this unique opportunity to study the microCT-scan images of *M. faustoi* – to approach in detail the anatomy and phylogenetic relationships of this extinct species of the family Molossidae. A second undescribed bat skeleton from the same paleosite, potentially *M. faustoi*, could be also part of the forthcoming research effort.

**Funding Sources** FAPERJ 200.101(242090)

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Preparators' Session (Thursday, October 19, 2023, 8:00 AM)

**CHALLENGES AND SOLUTIONS FOR RECOVERING QUATERNARY SMALL FELINE FOSSILS FROM THE DUNGEON, A PIT ROOM DEEP WITHIN NATURAL BRIDGE CAVERNS, COMAL COUNTY, TEXAS.**

Moretti, John A.

Geosciences, The University of Texas at Austin, Austin, Texas, United States

Caves and karst foster unique depositional settings capable of preserving exceptional samples of body and trace fossils, associated biomolecules such as collagen and aDNA, as well as abiotic evidence of paleoclimate. Accordingly, caves offer critical data for vertebrate paleontologists examining faunal and environmental change in the geologic past, particularly in the Quaternary. Yet, the physical settings of caves can be complex and dangerous, requiring technical skills and experience to navigate. Those challenges act to potentially limit our ability as paleontologists to access and interpret the fossil record.

Skeletal remains preserved deep (>1.2 km) within Natural Bridge Caverns in Comal County, Texas, offer insights into small feline diversity and distribution in the late Quaternary. The condition and location of those fossils, however, made recovery complex. The skeletal elements occurred in a pit room known as The Dungeon that is accessible only through a ~24 m vertical shaft. Skeletal elements were embedded in and protruded from two thin, brittle flowstone (i.e., calcite formation) slabs broken loose and moved, but not collected, during the initial exploration of the cave in the early 1960s. Transporting these specimens out of the cave required navigating other obstacles, including a tight squeeze crawl. In this presentation, I report on the methods and approach that a team of cavers and I utilized to collect this important sample as well as our results. We used standard SRT (single rope technique) ropework methods to rappel into The Dungeon. The slabs were encased in plaster jackets that were then padded with foam sheets, placed in hard plastic cases, and hoisted from the room. Once out of The Dungeon, those protective layers made it possible to safely maneuver the fossil bearing slabs through the tight squeeze and across other obstacles. Those methods to preserve the samples were successful with only minor, easily repairable damage to a small minority of skeletal elements.

Application of standard methods from paleontology and speleology allowed us to overcome physical barriers and collect these important specimens. Recovery of these specimens also allowed us to overcome a gap in knowledge, produced by a lack of field notes and loss of living memory, to clarify our understanding of other feline samples collected during the early exploration of Natural Bridge Caverns 60 years earlier.

**Funding Sources** This research was funded by Natural Bridge Caverns and Wuest Legacy Partners, Ltd.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**NEW EVIDENCE OF LATE PLEISTOCENE VERTEBRATE DIVERSITY AND CHRONOLOGY FROM AN ONGOING INVESTIGATION OF INNER SPACE CAVERN ON THE EDWARDS PLATEAU OF TEXAS.**

Moretti, John A.

Geosciences, The University of Texas at Austin, Austin, Texas, United States

Inner Space Cavern (ISC; aka Laubach Cave) is a show cave in the Edwards Limestone of central Texas. Investigations in the 1960s recovered rich samples of late Pleistocene faunal remains from four spatially discrete debris cone deposits. Those debris cones may have formed asynchronously over millennia and may, together, constitute a composite sequence documenting the vertebrate community prior to extinctions in the terminal Pleistocene. This setting is potentially ideal for addressing questions of the timing and driver(s) of late Pleistocene faunal change. Yet, the age and faunal relationships among debris cones are still unclear.

I conducted systematic excavations of five late Pleistocene deposits throughout ISC. Four of the five excavations encountered stratified sediments with diverse faunal assemblages. Analysis of those samples is incomplete and ongoing, but some notable occurrences and trends are apparent in the preliminary data. The remains of bats are common to each of the sampled deposits and appear to document changes in habitat use and/or species diversity through time. Only *Perimyotis subflavus* occurs in the cave today, yet this species has not been observed in Pleistocene samples. Instead, a large species of *Myotis* occurs in at least four of the five excavated samples and free-tailed bats (Molossidae) occur in at least two. Birds, including a dove (Columbidae), quail (Odontophoridae), hawk (*Accipiter* sp.), and multiple songbirds (e.g., aff. Parulidae), are recorded from ISC for the first time. Other new occurrences include anguid lizards, *Hesperotestudo* sp., *Kinosternon* sp., two camelids, and *Capromeryx furcifer*. Extralimital taxa include the prairie dog *Cynomys* and an ambystomatid salamander. *Equus* sp. and *Dasypus* cf. *D. bellus* are the most abundant and widespread of extinct forms recovered, but *Aenocyon*, *Platygonus*, and a large antilocaprid also occur. Associated elements of a jaguar (*Panthera onca*) add to two partial skeletons collected in the 1960s. Overall, taxa identified previously as unique to individual debris cones are now recognized in other deposits, demonstrating that those differences were the product of sample bias, not community change. Differences in fossil preservation, taxon occurrence, and taphonomic mode are apparent and suggestive of changes in past environments and/or communities. Ongoing faunal analysis and forthcoming radiocarbon ages may help to further clarify the age relationships among taxa and deposits.

**Funding Sources** This research is supported by the Texas Academy of Science, Jackson School of Geosciences (The University of Texas at Austin), and the Cleveland Grotto.

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Romer Prize Session (Thursday, October 19, 2023, 8:00 AM)

## HANDLING THE PRESSURE: CONVERGENCE IN VASCULAR ADAPTATIONS FOR MITIGATING HYDROSTATIC PRESSURES ASSOCIATED WITH DIVING IN MOSASAURS AND PLESIOSAURS

Morgan, Donald J.

Biological Sciences, Ohio University, Athens, Ohio, United States

Mosasauroidea and Sauropterygia independently evolved pelagic lifestyles and thus provide an opportunity to examine adaptation to an aquatic environment. Here I explore the roles of convergence and constraint in the evolution of physiological solutions to problems posed by diving as they pertain to hydrostatic pressures and thermal biology. Specifically, cephalic vasculature is vital to maintaining optimal brain temperatures and to mitigating effects of increased external pressure. The venous system of diving tetrapods is prone to collapse due to increased hydrostatic pressure, constraining reinvasion of aquatic environments and dive depth. Best studied in mammals, many extant diving amniotes evolved mechanisms whereby venous blood is shunted to vessels protected from collapse by surrounding bone. This project explores whether reptiles—especially extinct marine reptiles—evolved similar mechanisms. Osteological correlates (OCs) for cephalic vessels were identified in a broad sample of extant sauropsids using barium-latex injections followed by microCT. Mosasaur and sauropterygian specimens were then surveyed for these OCs via direct observation of the fossils and CT scan data. Based on contrast-enhanced (diceCT) studies, ancestral character state reconstruction using a maximum likelihood criterion allowed proportional assessment of the constituents of the dorsal alveolar canal (DAC) of extant sauropsids. Including fossils, the DAC in mosasaurs was likely evenly partitioned between nerve, artery, and vein, whereas sauropterygians had a higher proportion of nervous tissue, similar to extant archelosaurs. Quantitative analyses show that both plesiosaurs and plioplatecarpine mosasaurs convergently evolved adaptations to increase blood flow through bone-enclosed spaces (dural venous sinuses, spinal veins) allowing venous return to the heart but bypassing the

jugular system which was prone to hydrostatic collapse during diving. Interestingly, these clades evolved different solutions to achieve the same result: plesiosaurs emphasized dural sinuses whereas plioplatecarpines evolved novel basicranial channels. Emphasis on enlarged dural veins would also serve as a possible thermoregulator for the brain. Similar adaptations are seen in the enlarged internal vertebral veins of extant cetaceans and pinnipeds, illustrating the functional importance of protecting venous drainage of the head from the effects of external pressure in secondarily aquatic tetrapods.

**Funding Sources** Ohio Univ. Heritage Coll. Osteopathic Med., OU Student Enhancement Award (SEA), OU OCEES Fellowship Award

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Technical Session 4: Dinosaur Soft Tissues (Wednesday, October 18, 2023, 1:45 PM)

**SYSTEMATIC REVIEW OF EVIDENCE FOR AND AGAINST THE PRESENCE OF EXTRAORAL TISSUES IN NON-AVIAN DINOSAURS**

Morhardt, Ashley C.[1], Nabavizadeh, Ali[2]

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For over a century, paleontologists have speculated about how best to reconstruct extraoral soft tissues in non-avian dinosaurs. Interest in this topic is driven both by important questions of oral biology (e.g., oral digestion, dental development and maintenance, behavioral display) as well as by a desire to depict dinosaurs accurately. Arguably, the amount of interest in the topic outweighs the limited evidence available for analysis. To date, no systematic review has considered discussions of extraoral tissues in the literature. Here, we offer this review, which: (1) encompasses aspects of the oral cavity that would offer insight into extraoral tissue reconstruction; (2) takes stock of quantity and quality of evidence for relevant anatomical structures; and (3) offers a synthesis of the broad diversity, nuanced findings, and opinions from the literature. We reveal nuanced ambiguity in interpretation of relevant anatomical structures and considering their evolutionary history. Neurovasculature and "nutrient" foramina, as well as bone texture and other foramina along the oral margin, are often cited in arguments both for and against the presence of dermal extraoral tissues; however, there challenges remain their interpretation given uncertainty of extent of nerves and blood vessels within internal canals. Tooth types, morphologies, replacement patterns, and gingiva in dinosaurs–as well as how they differ from extant examples to which they are compared–are topics often neglected when speculating extraoral dermal tissues. Additionally, deducing extent of caudal expansion of extraoral structures is unclear, as bony correlates for rictal plates, jaw muscle attachment, and surrounding mucosa are both similar and potentially absent. Correlates of caudal extent of a rhamphotheca (beak) in many herbivorous dinosaurs are also often ambiguous. Without mummified remains, it is arguably not yet feasible to deduce if ornithischians or sauropods would have had "lip"-like extraoral tissues or a "cheek"-like buccal dermal sheet covering dentition (except in known cases of a buccal osteoderm in some nodosaurids). Ultimately, this review identifies, discusses, and prioritizes gaps in the literature that represent potential future directions for studies of extraoral tissues in extinct dinosaurs.

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Technical Session 15: Paleoecology & Paleoclimatology (Friday, October 20, 2023, 1:45 PM)

**A MULTIVARIATE COMPARISON OF INLAND AND COASTAL VERTEBRATE COMMUNITIES FROM THE LATEST CAMPANIAN OF ALBERTA, CANADA WITH IMPLICATIONS FOR VERTEBRATE BIOGEOGRAPHY**

Morley, Nathaniel E.[1], Leighton, Lindsey R.[1], Koppelhus, Eva B.[2], Currie, Philip J.[2]

[1]Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, Alberta, Canada, [2]Department of Biological Sciences, University of Alberta, Edmonton, Alberta, Canada

The terrestrial biota of the latest Campanian and early Maastrichtian of Alberta, Canada is largely represented by two geological units: the Horseshoe Canyon Formation and the Wapiti Formation. The strata of these formations were deposited in one geographically contiguous basin, with the former representing a coastal setting and the latter representing a somewhat more inland setting. The numerous well-sampled bonebeds from these

formations provide an excellent opportunity to test whether a coastal-to-inland environmental gradient led to vertebrate endemism in the Western Interior Basin, as has been previously hypothesized by numerous qualitative studies. This study used ordination and statistical techniques on both occurrence- and abundance-based data to test for compositional heterogeneity among eight well-sampled (>100 identifiable specimens) bonebeds from the Horseshoe Canyon-Wapiti system during a 2.7 Myr time interval in the latest Campanian. The results indicated that there is no significant compositional difference between the two formations, failing to support prior claims of vertebrate endemism resulting from a coastal-to-inland environmental gradient in the Western Interior Basin. Although these results challenge our current understanding of vertebrate biogeography in the upper Cretaceous of North America, they are supported by palaeogeographical and paleoenvironmental studies that demonstrate the Western Interior Basin is too geographically and environmentally homogenous to restrict the distribution of large-bodied vertebrates, such as dinosaurs. Furthermore, these results are supported by the nonmarine invertebrate record, which shows no clear signs of provincialism in the Western Interior Basin despite their propensity towards such patterns. Hence, the results from this study demonstrate the importance of assessing community-level data before drawing inferences on the community paleoecology of a given system.
**Funding Sources** This research was supported by a NSERC USRA awarded to NEDM and NSERC Discovery Grants awarded to LRL (DG202102744) and PJC (RGPIN-2017-04715).

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Preparators' Session (Thursday, October 19, 2023, 8:00 AM)

### LIMPING ALONG: CONSERVATION OF A PATHOLOGICAL *SMILODON FATALIS* PELVIS AND FEMUR FOR EXHIBITION FROM RANCHO LA BREA, CALIFORNIA

Morley, Stevie, Potze, Stephany

Research & Collections, La Brea Tar Pits & Museum, Los Angeles, California, United States

Development for an exhibit required conserving fossils of a dysplastic *Smilodon fatalis* pelvis (LACMHC 131) and femur (LACMHC 6963) from Rancho La Brea, a late Pleistocene paleontological locality in Los Angeles, California. All fossils were excavated and prepared in 1913-1915. Lacking archived preparation data, observations and general knowledge of historical practices guided conservation.

Morphology was obscured by asphaltic matrix on LACMHC 131 and LACMHC 6963. Both fossils were brittle, with friable cortical diaphysis on LACMHC 6963. Test patches of 1 $cm^2$ on LACMHC 131 and LACMHC 6963 were treated with acetone, then with 80°C H2O to identify adhesives based on interactions with these substances. Results revealed glyptal and white glue. A degreasing solvent, Novec 73DE, was applied to surface asphaltic matrix with foam tip applicators (FTAs) and nylon paint brushes. Surface glyptal was removed with acetone and FTAs, white glue with 80°C $H^2O$ and cotton swabs. Paraloid B72 (B72) in acetone was used for consolidation and <1 mm crack repair. Cracks ≥1 mm wide were filled with B72 and 12 gsm Nasu Kozo paper (Kozo). Excess B72 was removed with acetone.

LACMHC 131 required additional conservation. A metal rod connecting and supporting the iliac wings had loosened from degraded adhesive. Two gaps in the ramus had been filled with white glue and plaster. These were covered with 30 gsm Kozo and B72 during initial conservation to prevent damage and separation. Kozo was removed in sections and fillers were treated with 80°C $H^2O$ applied with nylon and boar bristle brushes. Fillers were removed in sections with dental tools and tweezers. After air drying, sections were filled by layering torn pieces of 12 gsm Kozo and B72. These pieces of Kozo were applied with tweezers and a nylon bristle brush with acetone. A layer of 15 gsm Kozo was placed over the 12 gsm Kozo for additional support. Excess B72 was removed with acetone.

Conservation data was recorded in written documentation and time-lapse videos, with weekly assessment photos. A Standard Operating Procedure was compiled with instructions for plaster and adhesive removal. This conservation was successful, but there was a degree of uncertainty that the use of quantitative methods for identifying adhesives would have alleviated. Such methods have not historically been used at RLB. This project demonstrates the utility of such methods to decrease uncertainties when drafting conservation plans for preparation.

**Funding Sources** Thanks to the Natural History Museum of Los Angeles, County, La Brea Tar Pits & Museum, M. Balisi, C. A. Clarke, A. Farrell, E. Lindsey, A. Novie & G. Takeuchi.

Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**A TYRANNOSAUROID BRAINCASE FROM THE EARLY CRETACEOUS OF THE ISLE OF WIGHT (U.K.) AND ITS IMPLICATIONS FOR THEROPOD EVOLUTION AND DIVERSITY**

Morrison, Cassius[1], Mannion, Philip D.[2], Porro, Laura[3], Barrett, Paul[4]

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Theropod remains from the Lower Cretaceous Wessex Formation of the Isle of Wight, U.K., are rare and often fragmentary, making the phylogenetic placement of several species questionable. Moreover, as some specimens have yet to be identified with confidence, and have not always been studied in detail, there is the possibility of a more diverse theropod assemblage than currently recognized. Theropod cranial material from the U.K. is scarce in general, with preserved braincase elements all referred to Megalosauroidea. Based on first-hand observation and micro-CT scan data, we present a previously undescribed braincase from the Wessex Formation. It represent the first braincase referrable to a coelurosaur from the Mesozoic of the U.K., is attributed to Tyrannosauroidea based on its rounded rectangular occipital condyle and the relative size of the foramen magnum. It differs from other theropod groups, in which the occipital condyle is dorsoventrally depressed and kidney-shaped (early-branching theropods), sub-spherical (Abelisauroidea), spherical (Spinosauridae) or elliptical (Carcharodontosauridae and Maniraptora). The occipital condyle of the new specimen is slightly larger than the foramen magnum, differing from Abelisauroidea and Carcharodontosauridae, in which the occipital condyle is significantly smaller than the foramen magnum, and maniraptorans in which it is significantly larger, but it is similar to those of the megaraptoran *Murusraptor* and the tyrannosaurid *Daspletosaurus*. The prominent paracondylar recesses are also indicative of a tyrannosauroid identification. Globally, three-dimensionally preserved crania of early-diverging coelurosaurs are rare and largely incomplete, so this new specimen provides important information for their evolution. As overlapping material is lacking, the braincase cannot be assigned to *Eotyrannus*, the only tyrannosauroid otherwise known from the Wessex Formation. Theropod braincases are often described as morphologically and phylogenetically conservative, but braincase phylogenetic characters potentially provide essential data that could help resolve and refine theropod phylogeny. Features like the ratios between foramen magnum and occipital condyle width are potentially synapomorphic for different theropod clades. The discovery of this new specimen increases our knowledge of Early Cretaceous European tyrannosauroids and might hint at a greater diversity of these taxa than previously suspected.

Virtual Posters

**HEDGEHOG PALEONEUROLOGY: VIRTUAL BRAIN ENDOCAST OF *POSTPALERINACEUS VIRETI* (EULIPOTYPHLA, MAMMALIA) AND COMPARISON WITH EXTANT ERINACEIDAE**

Moya-Costa, Raquel[1], Bertrand, Ornella C.[2], Luján, Àngel H.[3], Casanovas-Vilar, Isaac[2], Furió, Marc[4]

[1]Institut Català de Paleontologia Miquel Crusafont - Universidad de Zaragoza, Cerdanyola del Vallès - Zaragoza, Spain, [2]Institut Català de Paleontologia Miquel Crusafont, Cerdanyola del Vallès, Barcelona, Spain, [3]Institut Català de Paleontologia Miquel Crusafont- Masaryk University, Cerdanyola del Vallès- Brno, Spain, [4]Departament de Geologia, Universitat Autònoma de Barcelona, Institut Català de Paleontologia Miquel Crusafont-Serra Húnter Fellow, Cerdanyola del Vallès, Barcelona, Spain

Spiny hedgehogs (Erinaceinae, Eulipotyphla, Mammalia) are mainly represented in the fossil record by teeth, mandibles and maxillary fragments. Their teeth have a very conservative morphology, therefore large gaps remain regarding the evolution and paleobiology of the group, especially in aspects related to behavioral ecology. When recovered, cranial elements can provide crucial information because anatomical variation is clearly present within Erinaceinae and some diagnostic characters are

related to the morphology of the palate and orbital regions. One aspect that has not been explored relates to the usefulness of the endocranial anatomy to decipher the evolution of the senses and behaviors within Erinaceinae.

Here, we describe the endocranial anatomy of a fossil hedgehog from the Miocene site of Can Trullars 1 in Villadecavalls (9.4 Ma; Vallès-Penedès Basin, Catalonia, Spain). The specimen is an almost complete cranium, which was designated as the holotype for *Postpalerinaceus vireti* in 1947.

The endocranial cavity is relatively well preserved and allows us for the first time to reconstruct the brain endocast of a Miocene Erinaceinae. *Postpalerinaceus vireti* was scanned using microcomputed tomography (microCT) and, based on the generated CT data, we segmented the virtual brain endocast and further measured different brain regions for this specimen. Then, we compared it to the virtual brain endocasts of extant Erinaceidae, including the Erinaceinae *Erinaceus europeaus*, *Erinaceus roumanicus*, *Atelerix albiventris* and *Hemiechinus auritus,* and the Galericinae *Podogymnura truei* and *Echinosorex gymnura*.

The olfactory bulbs are dorsoventrally flat and laterally wide, and the circular fissure is short. In dorsal view, the cerebrum is wider than long as in both species of *Erinaceus*. The total volume of the endocast of *P. vireti* is approximately 3.4 $cm^3$, falling in the range of extant species and resembling *E. roumanicus*. The relative volume of the olfactory bulbs compared to the total volume of the brain endocast is about 10%, while the petrosal lobule volume ratio is about 0.7%, similar to the extant erinaceids. With these characteristics, we can determine that the brain endocast of *P. vireti* already had a modern appearance, which would suggest little sensory changes in Erinaceinae during the last 9 million years. Further work on this brain endocast will provide a better understanding of the sensory evolution in this group.

**Funding Sources** PID2020-117289GB-I00(MCIN/AEI/10.13039/501100011033/), GenCat/CERCA Programme, AGAUR (2021 SGR 00620, 2021 SGR 00127, 2021 BP 00042, 2019 BP 00154), MIU-NGEU MS.

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**HIDDEN MAMMALIAN DIVERSITY REVEALED BY EDENTULOUS JAWS FROM THE UPPER CRETACEOUS (LATE CAMPANIAN) PRINCE CREEK FORMATION OF NORTHERN ALASKA**

Munoz, Xochitl[1], Eberle, Jaelyn J.[2], Erickson, Gregory M.[3], Druckenmiller, Patrick S.[1]

[1]University of Alaska Museum of the North, University of Alaska Fairbanks, Fairbanks, Alaska, United States, [2]Museum of Natural History and Geological Sciences, University of Colorado, Boulder, Colorado, United States, [3]Department of Biological Science, Florida State University, Tallahassee, Florida, United States

The Upper Cretaceous Prince Creek Formation (PCF) of northern Alaska provides unparalleled insight into the diversity of high-latitude Mesozoic vertebrates, as it preserves a rich assemblage of avian and non-avian dinosaurs, fishes and mammals. Mammals remain a poorly known component of this Arctic ecosystem. On the basis of dental remains alone, four taxa have been recognized: an endemic pediomyid metatherian, *Unnuakomys hutchisoni*; a very small gypsonictopid eutherian; and two undescribed multituberculates. Ongoing microvertebrate analyses of three new productive sites along the Colville River have greatly expanded our sample of mammalian teeth as well as non-dental material including edentulous partial dentaries. Through comparative morphological analyses of these jaws, we recognize minimally five different morphotypes of non-multituberculate mammals based on differences in the angular processes, masseteric fossae, mandibular foramina, mental foramina, alveolar shapes, and height and width dimensions. Curiously, multituberculate dentaries have yet to be recovered. Assuming two of these morphotypes belong to the previously recognized taxa based on teeth, there are then three additional non-multituberculate taxa recognizable from these dentaries. Combining all available data, at least seven mammalian taxa can be recognized in the PCF, nearly doubling the previously recognized diversity. This additional diversity is supported by ongoing studies of mammalian teeth in the formation. These findings demonstrate that dental evidence alone may not always fully reveal the entirety of mammalian diversity in paleoecological studies. This newly expanded richness also provides important information to test hypotheses of latitudinal biodiversity gradients in Late Cretaceous ecosystems of Laramidia.

**Funding Sources** Funding Sources: National Science Foundation EAR 1226730 and EAR 1736515; University of Alaska Fairbanks Undergraduate Research and Scholarly Activities grant to XM.

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Paleontological Management Poster Session
(Wednesday, October 18, 2023, 4:30 - 6:30 PM)

## BEST PRACTICE GUIDELINES FOR MITIGATION OF ADVERSE IMPACTS TO PALEONTOLOGICAL RESOURCES

Murphey, Paul C.[1], Knauss, Georgia E.[2], Demeré, Thomas A.[1], Spivak, Dan[3], Moreno, Karen[4], McComas, Katie[1]

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The Society of Vertebrate Paleontology (SVP) strives to preserve and protect paleontological resources, particularly vertebrate fossils, and fossil localities. Mitigation paleontology entails the recovery and conservation of fossils that are threatened by human activities including ground disturbance, vandalism, and poaching. It is also increasingly used to recover and conserve fossils that are not threatened by human activities but that have been determined to be in danger of destruction by natural forces such as weathering and erosion. In 1991 (along with subsequent updates in 1995, 1996, and 2010), SVP's then-standing Impact Committee developed guidelines for conformable impact mitigation for nonrenewable paleontological resources. However, the guidelines were concerned primarily with paleontological resources on federal, state, county, and city lands in the USA. The revised best practice guidelines represent efforts made by a working group consisting of SVP members who are professional mitigation paleontologists in collaboration with SVP's Government Affairs Committee and Collections and Repository Committee, to expand the scope to be globally applicable with input from paleontologists, the mitigation community, natural history museums, and government agencies around the world. The best practice guidelines include a statement of purpose and need, general preconditions for the impact mitigation process, and recommended minimum qualifications for professional mitigation paleontologists. The mitigation process best practices are described and organized into nine phases. These include permitting, paleontological resource impact evaluation, field data collection, field surveys, monitoring of ground disturbance, fossil specimen recovery, data management and reporting, museum curation, and business ethics and scientific rigor.

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Technical Session 20: Marine Mammals & Bats
(Saturday, October 21, 2023, 1:45 PM)

## A GHOST ON THE COAST: MORPHOLOGICAL, ISOTOPIC, AND GENOMIC INSIGHT INTO THE EXTINCTION OF THE SEA MINK (*NEOGALE MACRODON*)

Mychajliw, Alexis M.[1], Olson, Olivia L.[1], Spiess, Arthur[2], Newsom, Bonnie[3], Abin, Chris[4], Hughes, Karissa S.[4], Paige, Victoria[4], Parker, Lilly[4], Snyderman, Lucia S.[1], Soctomah, Donald[5], Turvey, Samuel[6], Welch, Linda[7], Williams, Sara[4], Rick, Torben[8], Hofman, Courtney A.[4]

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Mammalian carnivores play crucial ecological roles in the systems in which they exist. While significant attention is paid to the extinction and ongoing endangerment of large carnivores, less is known about the dynamics of small carnivore losses across the Holocene. The sea mink (Mustelidae: *Neogale macrodon*) –called "supeqi-ciyahkehsu" by Wabanaki people– was a hypothesized sister taxon of the American mink (*N. vison*) that disappeared from the Gulf of Maine in the early 20$^{th}$ century due to presumed overharvest. Historical trapping ledgers record the sea mink as an exceptionally large, reddish mink with a fishy odor. Despite this massive harvest, paradoxically, no pelts from this species persist, leaving us with only skeletal remains from coastal

and insular archaeological shell midden sites.

To refine an extinction chronology for the sea mink and determine the full scope of what evolutionary and ecological diversity has been lost from the Gulf of Maine's carnivore community, we conducted an integrative study employing techniques including radiocarbon dating, stable isotope analysis, morphometrics, and paleogenomics. First, we assembled a comprehensive dataset of mink spatiotemporal occurrence to map extinction, including 12 newly generated AMS radiocarbon dates and 52 associated dates on archaeological materials spanning the Mid Holocene through the historical period. We then evaluated >200 archaeological mink and >100 modern American mink mandibles and crania, comparing dental measurements as well as ecomorphological metrics such as relative blade length and grinding area of molars. Sea minks were both larger than American minks and likely consumed tougher food items. These morphological results were corroborated by stable isotopes (δ15N and δ13C) of sea minks within a single temporal and ecological context – the Allen Island site – by analyzing both predator and prey isotope values, indicating a diet reliant on intertidal resources. To test whether sea minks formed a monophyletic clade, we compared whole mitochondrial genomes of sea minks to modern American minks found in the Gulf of Maine, presenting a complex view of post-glacial genetic lineages. We synthesize these distinct lines of evidence to illuminate a heretofore understudied branch of the carnivore tree of life and re-interpret present day management dilemmas. Has there been an ecological ghost haunting the coast of Maine – or have American minks stepped into this lost role all along?

**Funding Sources** This research was supported by the NSF Dynamics of Integrated Socio-Environmental Systems program (#2109168) and the Conservation Paleobiology Research Network.

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Education & Outreach Poster Session (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**THE POKÉMON POP-UP MUSEUM: SUPPORTING STUDENT LEARNING THROUGH SPECIMEN-BASED COMMUNITY OUTREACH AT A SMALL LIBERAL ARTS COLLEGE**

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Traditional organismal biology classes, such as vertebrate paleontology, tend to focus on memorization and evaluate students via high-stakes practical examinations. Yet, education research increasingly shows that such pedagogical practices are not effective for long-term information retention and do not build critical thinking skills. What are the alternatives? We provide a pedagogical case study in which students demonstrated their mastery of key organismal biology concepts and taxonomic and morphological features by developing their own collaborative outreach program, the Pokémon Pop-Up Museum. This event consisted of "pop up" temporary exhibits presented at a small liberal arts college in a rural community that otherwise lacks a natural history museum, making it applicable to a wide range of educational institutions and settings. This event was produced through joint lab sessions held by two organismal courses, Mammalogy and Entomology. We partnered with the nonprofit educational initiative Cosplay for Science to break down barriers of accessibility between science and the public in our outreach through the lens of pop culture, resulting in exhibits such as "Pokémon Pleistocene" and "Flying Type Pokécology". Student groups created a budget that included art supplies, cosplay clothing, Pokémon plushies, and other materials to create the immersive experience. The cross-pollination between classes created a synergy around our departmental learning goals; during the planning stages and dress rehearsal, students heard from their peers about familiar biological concepts applied to another taxon, a common learning outcome of our more specialized courses. While using Pokémon as a vehicle for communicating animal science in our world, students had the opportunity to develop and practice their science communication skills in a realistic outreach environment (not simply an artificial outreach project only read by the professor) that was also a service-learning opportunity. This event was extremely successful, attracting over 200 visitors over a 3-hour period in a rural community. The majority of attendees were families with young children, college students, and mentor-child pairs from the Community Friends program. Students were evaluated using a labor-based grading approach, cultivating an intrinsic motivation for project completion. This poster presentation will feature both an instructor and student participant presenter and perspective.

**Funding Sources** We thank the Center for Teaching & Learning and the Biology Department at Middlebury College for supporting this work.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

### A COMPARATIVE TAPHONOMIC ANALYSIS OF THE BUG CREEK ANTHILLS, A MIXED CRETACEOUS–PALEOGENE MICROFOSSIL BONEBED FROM NORTHEASTERN MONTANA

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The Bug Creek Anthills (BCA) microfossil bonebed in northeastern Montana occurs in the upper Hell Creek Formation in close proximity to the Cretaceous-Paleogene (K-Pg) boundary. The BCA is a fossiliferous channel-fill deposit that yields both non-avian dinosaurs and Paleocene mammals. The occurrence of both Cretaceous and Paleogene taxa at BCA has been used to argue for a gradual, non-catastrophic K-Pg mass extinction, but the current consensus (based mostly on the sedimentology of the site and adjacent areas) is that the BCA bonebed formed within a Paleocene river that reworked Late Cretaceous fossils. Here we investigate the taphonomy of the Bug Creek Anthills locality to test whether (1) it represents a thoroughly mixed assemblage of Late Cretaceous and Paleocene vertebrates or (2) pre- and post-extinction taxa are stratified within the BCA bonebed. We collected and sieved bulk sediment samples from eight 30-cm-thick increments, spanning bottom to top of the ~2.5-m-thick bonebed. Over 6,600 vertebrate microfossils in the >2 mm size fraction were recovered (smaller fossils from our collections await study). We focused on fossil richness, fossil size, shape, and quality, and taxonomy, and compared results from each sampled horizon. Fossil richness, quantified as total fossil mass, fossil mass percent, and number of specimens, was highest at the 60–90 cm and 180–210 cm horizons. Data on fossil size and shape, skeletal element type, overall taphonomic quality, and percent of identifiable skeletal material relate to reworking, and indicate that taphonomy was generally consistent throughout the locality. The most striking result is that taxonomic representation varied stratigraphically. Whereas fish, crocodiles, salamanders, lizards champsosaurs, and both Late Cretaceous- and Paleocene-aspect mammals were recovered throughout the deposit, strictly Cretaceous taxa such as *Myledaphus* and non-avian dinosaurs only appeared in the basal half of the BCA (0–120 cm). These data suggest that the BCA does exhibit some stratification of Late Cretaceous and Paleocene taxa and that the BCA assemblage may retain some temporal fidelity, contrary to previous interpretations of the site's nature and origins. Future work will focus on deciphering the taphonomy of the smallest fossils recovered from the BCA site (0.5–2 mm fraction). Preliminary observations indicate that fossils are plentiful in this size fraction.

**Funding Sources** David B. Jones Foundation

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Technical Session 12: Methods & Paleohistology (Friday, October 20, 2023, 8:00 AM)

### DEEP DIVE ON BONE COMPACTNESS AND STATISTICAL METHODS FOR RECOGNIZING SIGNIFICANCE IN THE INFERENCE OF LIFESTYLE IN SPINOSAURIDS AND OTHER DINOSAURS

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Bone microanatomy metrics and their correlation to lifestyle have been studied for decades in extant secondarily semiaquatic and aquatic tetrapods. A recent study of spinosaurid dinosaurs used global bone compactness (*Cg*) and a relatively new statistical method, phylogenetic flexible discriminant analysis (pFDA), to infer that *Spinosaurus* and *Baryonyx* were habitually diving "subaqueous foragers" and that the closely related *Suchomimus* was not. We examined the basis for these conclusions and found issues at multiple levels.

The analysis represented taxa by a single *Cg* value, yet we found substantial biological variation in *Cg* with the ontogenetic stage of the specimen, the location in the bone sampled, and among individuals. We also found substantial measurement uncertainty due to the source image used (thin-section, CT scan), the image threshold, and digital repair of fossil sections. The use of *Cg* to infer lifestyle is undermined by such variations, as well as by other confounding influences on *Cg*, including body size, herbivory vs. predation, the influence of skeletal pneumaticity in theropods, and evolutionary reduction of the hind limbs in *Spinosaurus*. Metrics of bone microanatomy such as *Cg* remain valuable tools for paleontology, but our findings show that further work is needed to establish their baseline statistical properties. We also examined the pFDA method, which has previous applications in paleontology. Like other statistical methods, its value depends on the quality of input datasets. We found several quality issues in the recent study of spinosaurids: many datasets are markedly imbalanced in composition between extinct and extant taxa; they include taxa of questionable relevance; and some assignments of lifestyle to taxa are erroneous. Crucially, the inputs also violate the pFDA requirement that data be normally distributed.

The accuracy of pFDA depends on sample size, an effect not previously studied. We used bootstrap analysis to examine sampling effects. We found that if the datasets used in the spinosaurid study are valid, their size alone makes classification by pFDA only marginally better than random chance, even when applied to the original training datasets. In sum, we found no compelling evidence to infer habitual diving lifestyle in any spinosaurid on the basis of *Cg* and pFDA. Our conclusions are consistent with other lines of evidence that suggest that these taxa were adapted to shallow water feeding in coastal and riparian habitats.

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Technical Session 1: Sauropod & Ornithischian Dinosaurs (Wednesday, October 18, 2023, 8:00 AM)

**EVOLUTION OF CRANIAL ADDUCTOR MUSCLE ORIENTATION IN ORNITHISCHIAN DINOSAURS AND ITS IMPLICATIONS FOR FEEDING MECHANISMS**

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Although numerous studies have investigated ornithischian jaw mechanics, few have explored how muscle orientation affects jaw motion evolution. Here, cranial musculature is reconstructed in 50 ornithischians to measure 2D angles of jaw muscles specifically with caudodorsal vectors (for involvement in both orthal and palinal jaw motions). These muscles include m. adductor mandibulae externus (mAME) and m. adductor mandibulae posterior (mAMP). Evolutionarily, trends in muscle orientation as well as relative muscle attachment breadth implicate the extent to which orthal and/or palinal jaw motions were used in overall feeding mechanisms. Results show widespread variation in muscle vector angles across taxa. Early-diverging taxa of all three major ornithischian clades (Thyreophora, Ornithopoda, Marginocephalia) show relatively lower-angled mAME and mAMP muscle vectors. Among thyreophorans, stegosaurs show mid-range to higher-angled vectors and ankylosaurs show a trajectory from high-angled vectors (early-diverging ankylosaurs and ankylosaurids) to, in some cases, lower-angled vectors (some nodosaurids). Among ornithopods, muscles range from lower-angled (early-diverging ornithopods) to mid-range vectors (non-hadrosaurid iguanodontians and most lambeosaurines) to higher-angled vectors (most saurolophines). Among marginocephalians, muscles show a trajectory from lower-angled (pachycephalosaurs and early ceratopsians) to higher-angled vectors (early-diverging neoceratopsians and leptoceratopsids), followed by a decrease in vector angles in protoceratopsids and especially low-angled vectors in ceratopsids. Since early-diverging taxa are orthal feeders, their low-angled muscles may implicate a bracing mechanism of their more restricted hinged jaw joint as caudally-oriented muscles were contracted in orthal closure. The increase in muscle angle in intermediate (and sometimes derived) forms within each group typically coincides with a rostrocaudally expanded temporal region and is likely, in part, for compensation of added palinal feeding with less restricted jaw joints. These adaptations help sustain both orthal and palinal feeding. The secondary lower-angled muscle vectors in ceratopsids, especially, is likely due to multiple factors, including growth of a rostrally-expanded mAME. These findings indicate that the diversity of ornithischian adductor chamber morphology is widespread and likely evolved in tandem with variable jaw joint morphologies.

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Technical Session 19: Theropods - II (Saturday, October 21, 2023, 1:45 PM)

**CRYPTIC SPECIES IN THE THEROPOD FOSSIL RECORD**

Napoli, James G.[1], Powers, Mark J.[2], Ruebenstahl, Alexander A.[3], Voris, Jared T.[4], Green, Todd L.[5], Turner, Alan H.[6], Flynn, John J.[7], Currie, Philip J.[2], Norell, Mark A.[7]

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Non-avian dinosaur taxonomy is typically based upon obvious morphological gaps between putative species. While this approach is likely to minimize type I error (“false positives”), it also carries a substantial risk of type II error (“false negatives”), especially given that most extant species are diagnosed by molecular or soft-tissue evidence alone. Well-sampled dinosaur species may therefore contain one or more “cryptic species”, that are distinguished by only subtle morphological characters. The lead author developed a new Bayesian method (BiDOV) that uses character data from modern species to determine the probability that two fossil specimens belonged to the same biological species, based upon observations of character variation in modern species. We use these data to present methodological refinements and expansions to BiDOV and report the results of its initial deployment to study of the fossil record. We evaluate hypodigms of three charismatic, well-sampled, and well-studied non-avian theropod dinosaurs – the tyrannosaurid *Gorgosaurus*, the oviraptorid *Citipati*, and the dromaeosaurid *Velociraptor*. All three genera show strong evidence of cryptic diversity when analyzed with BiDOV. The large sample of *Gorgosaurus* from the Lower Dinosaur Park Formation (DPF) of Alberta, Canada show consistent character differences when compared to the holotype of *G. libratus*, from the Upper DPF, indicating a new cryptic species and suggesting a stratigraphic separation of the two *Gorgosaurus* species now recognized. Cranial and postcranial characters differentiate a new species of *Citipati* from the holotype of *C. osmolskae*, notably including divergent hindlimb proportions that fall outside the range of variation in modern ground birds. *Velociraptor mongoliensis* appears to be a species complex, representing between two and four potential species. That all three of these theropod taxa proved chimeric corroborates our expectation that dinosaur taxonomy has been pervasively affected by type II error, and we predict that application of morphospecies delimitation criteria based upon observed variation in living species will lead to the discovery of many new extinct species. The recognition of cryptic species diversity in these and other theropods is almost certain to bring about significant changes in understanding of theropod systematics, paleobiology, and ontogeny, especially given the scientific importance of these three genera in bearing upon such questions.

**Funding Sources** AMNH Richard Gilder Graduate School (RGGS), Gingrich endowment, Theropod Dinosaur Research Fund (AMNH), Jurassic Foundation, and Theodore Roosevelt Memorial grant.

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Technical Session 15: Paleoecology & Paleoclimatology (Friday, October 20, 2023, 1:45 PM)

**DAWN OF THE CENOZOIC: POST-DINOSAUR-EXTINCTION PALEOENVIRONMENTS OF CORRAL BLUFFS, CO, USA**

Naprstek, Rebecca[1], Lyson, Tyler[2], Hunt, Piper[3], Burhoe, Vlordrik[3], Peyrat, Grace[3], Giammasi, Ryan[3], Fastovsky, David E.[1]

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The removal of non-avian dinosaurs from Cretaceous-Paleogene ecosystems at the end of the

Cretaceous allowed mammals to radiate and proliferate after the extinction. High-resolution insights into this terrestrial radiation have been captured at Corral Bluffs, CO, in which mammal and other vertebrate fossils collected within a detailed stratigraphic, geochronological, and paleomagnetic framework produced highly resolved time slices that capture key evolutionary steps during the terrestrial Paleocene radiation. Here we examine the earliest paleoenvironments in this setting, leading to a deeper understanding of this earliest Paleogene environment for this radiation.

Preliminary work hypothesized that immediately after the non-avian dinosaur extinction, Corral Bluffs was an unstable, low-sinuosity river system. We addressed this hypothesis by carrying out a detailed sedimentological analysis of a microsite locality, including field as well as laboratory petrographic analyses. A limited microfossil collection from this locality provided an additional test of the paleoenvironmental hypothesis.

Our analysis suggests that the Corral Bluffs microsite locality was part of a low-sinuosity river system. Units interpreted as channel deposits range from ~4.5 m – greater than 6 m in thickness, with erosive bases. Both high- and low-flow velocities are represented. The presence of rip-up intraclasts and large-scale cross-stratification indicate high flow velocities within coarser-grained deposits, with flow consistently northeast. Lower flow velocities are represented by very fine grained, laminated sandstones and small-scale cross-stratification in inferred floodplain settings, as well as pedogenetically weakly altered silt- and mudstones, features interpreted as localized ponds and incipient paleosols, respectively. The region was heavily vegetated and organically productive, as evidenced by the presence of root casts, small, isolated layers of coal, and dense deposits of macerated plant matter as well as whole leaves. The microsite locality shows evidence of very rapid sediment deposition, indicated by climbing ripple stratification and soft-sediment deformation.

This investigation confirms that the Corral Bluffs microsite formed within a very active low-sinuosity fluvial landscape characterized by high organic productivity.

**Funding Sources** Funding for this work was provided by the University of Rhode Island. Extensive field support was generously supplied by the Denver Museum of Nature and Science.

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Paleontological Management Poster Session (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**HUNTING FOR FOSSILS IN THE SUNSHINE STATE: MODERNIZING THE FLORIDA FOSSIL PERMIT PROGRAM**

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In Florida, fossil plants, invertebrates, and chondrichthyan teeth may be collected and kept for personal use. However, other vertebrate fossils collected from state lands are protected and their associated sites preserved through Florida Statute 1004.57, which was enacted in the 1980s. The Florida Museum (FLMNH) Program of Vertebrate Paleontology (VP) is the repository for these fossils and issues permits to collect vertebrate fossils on state lands (on average 1,875 permits/year). The program has been important for Florida paleontology with many significant discoveries made by amateur collectors who often donate fossils to the FLMNH for use in research, education, and outreach. However, in the past three decades, fossil hunting in Florida has become very popular and more commercialized with a large increase in fossil tourism, creating some new challenges. One issue is the vague language used in Florida Statue 1004.57 on permissible tool use when fossil hunting resulting in some permittees wrongly assuming that they can use shovels and machinery to dig into riverbanks and bottoms. In fact, these activities are generally not permissible and can cause significant environmental damage. Furthermore, many Florida vertebrate sites also have archaeological context, including sensitive Paleoindian sites protected under the Florida Historical Resources Act. Individuals collecting on these archaeological sites might intentionally use their Fossil Collecting Permit as a cover, although it is likely that most simply do not know the difference between artifacts and fossils or understand the broader archaeological context. To address these challenges, a committee including representatives from FLMNH VP, State Archaeologists, the Department of Environmental Protection, and Florida Fish and Wildlife Conservation has been meeting regularly since November 2022. Goals include updating the language on the program's website and permittee documentation to clarify how fossils can be collected on state land without violating existing laws related to archaeological sites and the environment, limiting multi-use permits, and capping the number of out-of-state permits issued/year. Future outreach includes identification guides to educate permittees (and law enforcement) on the differences between artifacts and fossils, and discussion with amateur communities about these changes, providing an avenue for community members to discuss their concerns directly with state officials.

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Technical Session 7: Birds (Thursday, October 19, 2023, 8:00 AM)

**WELL-PRESERVED ENANTIORNITHINE CRANIAL REMAINS ILLUMINATE COMPLEX ORIGINS OF THE MODERN BIRD CENTRAL NERVOUS SYSTEM**

Navalon, Guillermo[1], Chiappe, Luis M.[2], Benson, Roger[3], Martinelli, Agustín[4], Nava, William[5], Field, Daniel J.[1]

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Crown birds exhibit the largest brains among reptiles and the anatomy of their central nervous systems is highly modified from the ancestral non-avian condition. The enlarged, flexed brains and the modified vestibular systems (balance organ) of the inner ear that characterize some lineages of living birds are believed to have originated near the origin of the crown group. However, a lack of Mesozoic-aged, three-dimensional fossils hinders understanding of the evolutionary changes that gave rise to this unique configuration. Here, we demonstrate the occurrence of some of these ‘advanced’ traits in several stem-birds (Enantiornithes) by studying several cranial fossils from an Upper Cretaceous (~80 MYA) avian bonebed in south-eastern Brazil (William’s Quarry, Presidente Prudente, Sao Paulo State). Our work pushes back the origination of these key traits to a much earlier point along the avian stem lineage but underlines some important differences between the neuroanatomical configuration of enantiornithines and their extant avian counterparts. Furthermore, our quantitative comparisons with a large dataset of stem birds (including non-avian theropods) and neornithines support the notion that spatial constraints within the braincase profoundly affected the evolution of the avian brain and associated sensory structures. Altogether, our research reveals a significantly more complex picture of the early evolution of the avian brain than has previously been documented.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**SMALL MAMMAL REMAINS FROM RAPTOR PELLETS PERSIST ON TUNDRA FOR AT LEAST DECADES (ARCTIC NATIONAL WILDLIFE REFUGE, ALASKA)**

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Skeletal remains of small-bodied mammals contained in avian raptor regurgitates (pellets) can be used to assess changes in species composition across space, but the amount of time recorded by pellet accumulations is unknown, particularly in Arctic settings. Temporal richness of cave deposits and other protected long-term roosting sites at middle latitudes can achieve centennial- to millennial-scales of time-averaging, but few data are available for assessing the persistence of pellets and their skeletal remains on open landscapes or at high latitudes. Here, we provide a first estimate of the persistence of pellets on the Coastal Plain of the Arctic National Wildlife Refuge, Alaska. Quantifying the temporal richness of small mammal skeletal accumulations on the tundra is not only important for understanding the temporal depth of the available record but is key for understanding how skeletal accumulations record microtine rodent dynamics, which undergo significant and extreme population cycles. On the Coastal Plain, lemmings (*Dicrostonyx groenlandicus*, *Lemmus trimucronatus*) and voles (*Microtus oeconomus*, *Microtus miurus*) may expand their populations up to four times their original sizes before crashing back every three to four years. These

boom-bust cycles occur non-synchronously across the Coastal Plain, complicating efforts to understand differences in results from traditional mammal trapping surveys conducted in different regions and years. But is the duration across which small-bodied mammal remains persist on landscapes sufficient to average-out high-frequency variability in populations caused by boom-bust cycles? Here, raptor pellets (n=232) were collected during taphonomic surveys of openly vegetated tundra habitat (*Dryas* terraces) near the Canning, Katakturuk, Hulahula, Jago, Aichillik, Kongakut, and Turner Rivers. Pellets were visually inspected for traits such as moss overgrowth and bone discoloration. Four pellets representing the most aged specimens were AMS radiocarbon dated. To test the nature of the apparent taphonomic clock, one pellet that appeared to be much younger was also dated. We find that pellets on the Coastal Plain can accumulate over at least decadal timescales, successfully providing time-averaged samples of the small mammal community. Small mammal skeletal remains can accumulate for ecologically significant durations on high-latitude landscapes, providing opportunities for a variety of conservation paleobiological applications.

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**_CANIS RUFUS_ HAS CHANGED SIGNIFICANTLY SINCE THE IMPLEMENTATION OF THE CAPTIVE BREEDING PROGRAM, AND BOTH MORPHOTYPES ARE SIGNIFICANTLY DIFFERENT FROM NON-EASTERN _CANIS LUPUS_ AND _CANIS LATRANS_**

Nelson, Allison E.

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The origin of *Canis rufus* (red wolves) has been hotly contested. Three main hypotheses exist: 1. It is a native North American species distinct from the grey wolves that came across the Bering Land Bridge. 2. Red wolves never were a separate species but are instead hybrids between *Canis lupus* (grey wolves) and *Canis latrans* (coyotes). 3. It is a native North American species, but not distinct from the pre-Columbian “grey wolves” that inhabited the eastern seaboard. Due to nearly complete eradication and rampant hybridization with coyotes, a captive breeding program (CBP) began in the 1970s. In October 2021 the CBP had 266 red wolves. Whether red wolves are a separate species affects their Endangered Species List (ESL) status and therefore conservation funding, including the CBP. Without a clear definition of red wolf there cannot be a clear conservation goal. With so few individuals, it has not been clear what traits distinguish red wolves from grey wolves and coyotes. Recent years have seen the delisting and relisting of grey wolves which heavily disrupted conservation efforts.

Paleontological methods were used due to heavily mixed genetics, focusing on skull shape and measurements. Cranial geometric morphometric analysis was performed on 739 museum specimens of wild red wolves prior to the CBP, CBP individuals, coyotes, and specimens of wild and captive grey wolves. Procrustes analysis and one-way PERMANOVA (permutational multivariate analysis of variance) were completed. Wild 1970s red wolves are different from all but one wild grey wolf group (Eastern grey wolves (EG)) (p=0.03). Likewise, CBP wolves are different from all wild groups except for EG (p=0.008). This supports the third hypothesis. The second hypothesis is rejected by CBP wolves being significantly different from grey wolves and coyotes. Coyotes are significantly different from both wild red wolves and CBP wolves (p=0.0001 for both). Interestingly, CBP produced red wolves are significantly different (p=0.0002) from the initially selected wolves. The first hypothesis is rejected. This result that red wolves are a separate species from nearly all grey wolves supports their continued ESL listing. It is interesting that red wolves have changed significantly in the near 50 years of the CBP. This exemplifies the need for analysis indicating the unique traits of red wolves. Future studies may use these methods to determine species boundaries in closely related fossil groups.

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Technical Session 20: Marine Mammals & Bats (Saturday, October 21, 2023, 1:45 PM)

**SYSTEMATIC REVISION OF WASTEBASKET TAXA REFINES HYPOTHESES OF KEY EVOLUTIONARY TRANSITIONS: A CASE STUDY OF THE SQUALODONTIDAE (CETACEA)**

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The fossil record offers insight into significant evolutionary events throughout the geologic history of a clade, and few records offer the level of insight as that of the Cetacea. Although stem Cetacea possess a classic mammalian dentition with regionalization of the tooth row, crown Cetacea are freed from those constraints: the Mysticeti secondarily lose teeth and develop baleen-assisted filter feeding, whereas modern Odontoceti possess a homodont and polydont dentition. The evolution of polydonty and homodonty is decoupled in Odontoceti, as polydonty appears in the most basal odontocetes, while homodonty appears to be restricted to the crown group. Within crown Odontoceti, the only clade to have purported heterodont members is the Platanistoidea, which contains the south Asian river dolphins. Assessing phylogenetic hypotheses within the Platanistoidea is, in reality, testing hypotheses of convergent evolution in the odontocete dentition. The heterodont odontocetes hypothesized to be within the Platanistoidea include the Waipatiidae and the wastebasket taxon Squalodontidae. To understand the phylogenetic position of the Squalodontidae and transform it into a true clade, I redescribed historic squalodontid fossils and placed six squalodontids into phylogenetic analysis for the first time. My analysis included taxa from almost all crown odontocete clades, all major taxa hypothesized to be within the Platanistoidea, and the majority of known heterodont odontocetes. I made morphological comparisons of the dentitions of heterodont Cetacea and either modified or added 11 dental characters for a final matrix of 103 OTUs and 295 characters. This analysis was run in PAUP* using 1000 random-addition replicates under both equal and implied weights; I then ran a bootstrap analysis and calculated Bremer support to statistically evaluate the stability of key nodes. I obtained 624 MPTs with treelength 2917 under equal weights and a single MPT with a fit of -199.76. No heterodont taxa were identified as unstable using tree-pruning methods. All heterodont odontocetes were recovered outside crown Odontoceti under both equal and implied weights, in contrast to previous workers' phylogenetic analyses. My results do not support the convergent evolution of homodonty within the Platanistoidea—in fact, a functionally homodont dentition with only single-rooted teeth is recovered as a synapomorphy of crown Odontoceti.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**HARE-SIZED CAINOTHERIIDAE (MAMMALIA, ARTIODACTYLA) RELIED ON A FRUIT-DOMINATED BROWSING DIET**

Nesset Mattsson, Gustav[1], Mörs, Thomas[2], Semprebon, Gina M.[3], Kalthoff, Daniela C.[4]

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Microscopic scars on occlusal tooth surfaces are used to garner information on feeding ecology in extinct and extant mammals. We investigated the dietary adaptations of four species of Cainotheriidae, small-bodied, extinct even-toed ungulates that occurred from the Eocene into the middle Miocene in Europe. Because of their small size and slender build, their ecology is regularly compared to that of extant mouse-deer (Tragulidae), rainforest-dwelling and highly frugivorous mammals. Using a stereomicroscopic approach to examine dental microwear, we compared the results to microwear in extant mouse-deer and in dik-diks (genus *Madoqua*), small-bodied African antelopes and seasonal mixed feeders living in semi-arid savanna environments. We tested two hypotheses: 1) microwear features are similar to those in mouse-deer and dissimilar to dik-diks; and 2) microwear features show a climate-related shift in the diet of Cainotheriidae from older to younger species. We analyzed Oligocene *Caenomeryx filholi*, late Oligocene/early Miocene *Cainotherium commune*, early Miocene *Cainotherium laticurvatum*, and middle Miocene *Cainotherium huerzeleri* from France and Germany. At 70x magnification, we observed wear surfaces in all fossil species to be primarily coarse, featuring frequent large pits, crater-like puncture pits, irregularly bordered flat pits (gouges), as well as coarse and hypercoarse scratches. There are only minor, non-significant differences between the late Oligocene and middle Miocene taxa. Compared to extant Tragulidae, Cainotheriidae exhibited a very similar microwear scar profile in regards to pitting, though we found slightly more scratches of all sizes in mouse-deer. In contrast and as expected, *Madoqua* showed significant differences in all microwear features compared to both Cainotheriidae and Tragulidae. Our analysis suggests that Cainotheriidae had similar dietary preferences to modern-day mouse-deer, with fruits as primary food resource. Dik-diks, on the other hand, plot outside of the browsing ecospace range and fall within the mixed-feeder range. This supports our initial hypothesis that cainotheriids had similar dietary preferences to mouse-deer and different preferences when compared to dik-diks. Regarding our second hypothesis, we see no significant shift in food choice of cainotheriids that would indicate changing climate conditions.

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**NEW SAMPLES OF LATE CRETACEOUS (JUDITHIAN) MULTITUBERCULATE MAMMALS FROM THE JUDITH RIVER FORMATION OF HILL COUNTY, MONTANA**

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Multituberculate mammals were one of the most evolutionarily successful clades of Mesozoic mammals. The Judithian (North American Land Mammal Age) of the Late Cretaceous (Campanian) was a pivotal interval in their evolutionary history, when they reached significant levels of taxonomic and ecomorphological diversity. It also represents the lead-up and baseline environmental conditions before the Maastrichtian and the K/Pg mass extinction. However, Judithian local faunas have typically been analyzed in aggregate across this ~12-million-year interval; there has been little attempt to arrange these local faunas into a temporal sequence that would allow for a more detailed view of mammalian faunal dynamics during this critical interval. Here, we take a step toward this goal by describing new multituberculate fossils from new and existing sites in the Judith River Formation exposures of Hill County, north-central Montana.

In 2019 and 2022, we restarted dedicated vertebrate microfossil collecting in the Judith River Formation exposures near Havre and Rudyard, Montana, after a 25-year hiatus. We returned to the well-known fossil localities Makela-French 1 and Put's Plunder, ~43 km north of Rudyard. We also prospected in previously unexplored outcrops ~40 km northwest of Havre, where we identified eight new vertebrate microfossil localities. We surface-collected fossils at all localities and bulk-sampled only the most productive, collecting over 750 kg for underwater screenwashing. Fossil picking of new and previously collected sediment has thus far led to the recovery of over 200 isolated mammal teeth, mostly from Makela-French 1 and Put's Plunder. Recent revisions to multituberculate taxonomy and new occurrences in our fossil samples necessitate an update to the multituberculate faunal list for the Judith River Formation in Hill County. We document the presence of *Filikomys* as well as a new cimolomyid from the formation. We also place the Put's Plunder, Makela-French 1, and new localities from near Havre into a stratigraphic succession that will allow a preliminary evaluation of faunal dynamics within the Judith River Formation.

**Funding Sources** University of Washington; The Myhrvold and Havranek Charitable Family Fund

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**CONSPICUOUS PARIETAL ASYMMETRY IN TWO CENTROSAURINE TAXA FROM ALBERTA, CANADA**

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Most ceratopsid species are diagnosed based on the morphology of their cranial ornamentation. A *Styracosaurus albertensis* specimen described recently with conspicuous asymmetry on its parietosquamosal frill highlights how this type of deviation can complicate taxonomic descriptions. However, without an understanding of the range of potential variation, the phylogenetic implication from this asymmetric specimen remains contested: Holmes et al. 2020 argues that the parietal of *Rubeosaurus ovatus* does not differ enough to be a separate taxon from *S. albertensis*, while Wilson et al. 2020 maintains that it should be a separate *Styracosaurus* species.

In this study, we surveyed aberrant parietals from the two best-sampled centrosaurines – *Centrosaurus apertus* and *Pachyrhinosaurus lakustai* and the frequency of their occurrences within each taxon. We predict that asymmetry fluctuates and occurs randomly at a similar rate between the two taxa, which could help us establish a baseline range of morphological variation in centrosaurine parietals.

We found that conspicuous asymmetries occur on the parietals as a whole or/and on the epiparietal ossifications, chiefly the distalmost ones that deviated from their basic d-shaped morphology: P1-2 in *Centrosaurus* and P2-3 in *Pachyrhinosaurus*. Juvenile specimens where the epiparietals are still d-shaped or unfused and specimens with only one side preserved cannot be assessed for asymmetry. Our preliminary data indicate that, despite having a higher total number of specimens, asymmetry in *Centrosaurus* is low, limited to the epiparietals, and can be characterized as fluctuating. Meanwhile, the majority of *P. lakustai* specimens exhibit asymmetry in one or both pairs of epiparietals, with P2 showing directional asymmetry, and a few also exhibit parietal asymmetry. Additional analyses are in progress to quantify the asymmetry and identify those associated with a pathology. The cause behind this difference in asymmetry pattern between these two centrosaurines is currently unclear. As a socio-sexual signaling structure, an asymmetric frill was most likely not driven by behaviors like the headgear of some modern ungulates. The project shows that it is difficult to establish a baseline asymmetry rate for these taxa and emphasizes the need to increase sampling size for taxonomic stability, especially with species currently represented by fragmentary parietals.

**Funding Sources** Dinosaur Research Institute

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

## COMPARATIVE VERTEBRAL MORPHOLOGY AND INTERVERTEBRAL MOBILITY OF *SEYMOURIA*

Nolan, Travis

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Despite the abundance of research prompted by the alleged proximity of *Seymouria baylorensis* to the origin of the amniotic clade, relatively little is known about this intriguing organism from a biomechanical perspective. Here we report the results of geometric morphometric analysis used to contextualize the morphology of *Seymouria* vertebrae in relation to contemporaneous non-mammalian synapsids, as well as to modern squamates and amphibians whose locomotion can be directly observed. Our results show that the vertebrae of *Seymouria* cluster neatly with the sampled amphibians rather than with the squamates, which would lead us to suspect an amphibian mode of spinal mobility. To investigate this further, functional surfaces were generated across the resulting principal components plot to estimate intervertebral mobility in terms of axial torsion, lateral bending, and sagittal bending. We find that the *Seymouria* spine can best accommodate lateral bending and a restricted degree of axial torsion. Taken together, these findings suggest that modern caudatan amphibians may serve as an important model for studying the locomotion of *Seymouria*.

**Funding Sources** Funding for this research comes from the Dedman College Interdisciplinary Institute at Southern Methodist University.

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Technical Session 18: Synapsids (Saturday, October 21, 2023, 8:00 AM)

## DETERMINING CANINE REPLACEMENT IN THE SMALLEST INDIVIDUALS OF *THRINAXODON LIORHINUS* (THERAPSIDA, CYNODONTIA) USING X-RAY MICRO-COMPUTED TOMOGRAPHY

Norton, Luke A.[1], Benoit, Julien[1], Abdala, Fernando[2]

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The non-mammaliaform cynodont *Thrinaxodon liorhinus* is one of the most abundant representatives of the post Permian-extinction fauna from the *Lystrosaurus declivis* Assemblage Zone (Lower Triassic) of the South African Karoo Basin. Despite *T. liorhinus* being one of the most well-studied therapsid taxa with regards to tooth replacement, few previous studies have included the smallest 'early juvenile' specimens (basal skull length [BSL] ≤37 mm). Furthermore, this 'early juvenile' size class (BSL ~31–35% maximum adult size), is not represented in other cynodonts (e.g., *Cynosaurus* and *Galesaurus*) for which tooth replacement has been studied. A previous study focusing on dental morphology and replacement in juvenile *T. liorhinus* (n = 3; BSL ~30–33 mm) concluded that these specimens had paired maxillary canines. However, this result was not replicated in a more recent study using X-ray micro-computed tomography (µCT). That study included five µCT scanned specimens (BSL 37–87 mm), and a large sample of externally studied specimens (n = >50; BSL ~30–96 mm). Most studies have determined an alternating replacement pattern and a single pair of upper canines in *T. liorhinus*, with the replacement upper canine erupting mesial to the functional tooth. Studies of tooth replacement in inferred ontogenetic series of the basal cynodonts *Cynosaurus* (upper Permian) and *Galesaurus* (Lower Triassic) have found that canine replacement had ceased in larger individuals that had attained a BSL corresponding to the attainment adulthood. This differs from the results of similar studies in *T. liorhinus*, which demonstrated the continued replacement of the canines well after reaching adulthood. Here we present a detailed study on variation of the tooth replacement patterns in the smallest 'early juvenile' individuals of *T. liorhinus*, with a particular focus on the organization of the functional and replacement maxillary canines. For this study, we µCT imaged all six available 'early juvenile' individuals of *T. liorhinus* (BSL ~30–37 mm). We found that there was evidence for two replacement upper canines in these specimens, one distal and one lingual to the functional tooth. Thus, the youngest *T. liorhinus* likely had two upper canine families, with one lost during development. This condition more closely resembles that described for lycosuchid therocephalians than other juvenile cynodonts, supporting the hypothesis that paired upper canines was the plesiomorphic condition for Theriodontia.

**Funding Sources** GENUS DSI-NRF CoE Palaeosciences, Palaeontological Scientific Trust, Agencia Nacional de Promoción Científica y Tecnológica, Argentina, and NRF African Origins Platform

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Technical Session 16: Theropods - I (Saturday, October 21, 2023, 8:00 AM)

### HINDLIMB ALLOMETRY IN *UTAHRAPTOR OSTROMMAYSI* (THEROPODA: DROMAEOSAURIDAE) AND IMPLICATIONS FOR ONTOGENETIC SHIFTS IN PREDATION STRATEGIES AND NICHE PARTITIONING

Nye, Alexander J., Britt, Brooks, Scheetz, Rod

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A partial, associated theropod skeleton, BYU 20692, that includes several skull/mandibular elements, portions of all areas of the vertebral series, and a partial hind limb that includes a tibia and metatarsals II-IV, from the base of the Yellow Cat Member of the Cedar Mountain Formation compares favorably with *Utahraptor ostrommaysi*. The specimen's tibial length of 362 mm is 24% smaller than the average length of 490 mm for the six *Utahraptor* adult tibiae in the BYU collection. This suggests BYU 20692 is a juvenile and thin sections are being made to facilitate LAG analyses. In addition to the specimen's relatively small size, the hind limb is more gracile with a circumference to length ratio of the tibia of 0.27 and the same ratio for metatarsals II-IV being 0.32, 0.31, and 0.34, respectively, while in adults the same ratio for the tibia averages 0.39 and those of metatarsals II-IV are 0.38, 0.51, and 0.57. Another difference is that the metatarsal III to tibia length is 0.48 in BYU 20692, while in the average adult this ratio is 0.39. In sum, the tibia and metatarsal in the juvenile are more gracile and the metatarsus is longer relative to the tibia than in adults indicating ontogenetic allometry in *Utahraptor* hind limbs.

If the identification of BYU 20692 as *Utahraptor* is correct, juvenile *Utahraptor* individuals were more agile runners than adults. And, while the adults were not as fleet of foot, their limbs were more robust, providing extra strength and stability. These differences suggest younger individuals chased down smaller prey whereas adults were perhaps not as fast, their more robust legs were better suited to subduing and/or securing prey. Thus, the allometric growth of the hindlimb implies ontogenetic niche partitioning in *Utahraptor*.

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Technical Session 5: Ungulates (Wednesday, October 18, 2023, 1:45 PM)

### ISOTOPIC EVIDENCE OF SEASONALITY AND MIGRATION DURING THE LAST GLACIAL PERIOD OF KENYA

O'Brien, Kaedan[1], Podkovyroff, Katya[2], Fernandez, Diego P.[3], Tryon, Christian A.[4], Ashioya, Lilian[5], Cerling, Thure E.[3], Faith, J. Tyler[1]

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Paleoenvironmental reconstructions of the Last Glacial Period of eastern Africa paint a picture of a landscape dominated by grasslands and herds of diverse grazing herbivores unlike anywhere in modern Africa. However, the scale of such reconstructions is often at the site level and greatly time-averaged. To elucidate the impact of glacial conditions on tropical grassland animal behavior, a more direct proxy is needed. Using stable strontium, carbon, and oxygen isotopes, we reconstruct paleoenvironmental conditions and behavior of 18 bovid and equid species from four sites dating to the Last Glacial Period in Kenya (Karungu, Rusinga, Kibogo, and Lukenya Hill). In doing so, we address i) migration patterns, ii) seasonality of precipitation and diet, and iii) the role that seasonal responses played in niche separation of closely related species. We find that migration played a similar role in Last Glacial Period grasslands to what it does today but with a notably different set of species; that animals had relatively stable, grass-dominated diets year-round, peaking in $C_4$ grass abundance during the Last Glacial Maximum; that precipitation and seasonality fell within the range of modern eastern African ecosystems; and that a diverse guild of ungulate grazers was able to coexist due to niche separation detectable as isotopic differences. These results combine to extend the theory that eastern African grasslands were greatly expanded and resource-rich year-round during the Last Glacial Period, creating highly favorable conditions for grazing ungulates. Additionally, they demonstrate the geologic recency of the modern guild of migratory species in eastern Africa, which replaced a set of now-extinct migratory species once common in grasslands during the Last Glacial Period, most notably the enigmatic bovid *Rusingoryx*. Our results illustrate the ecosystem dynamics of Late Pleistocene Kenya on a scale not attainable with most other paleoenvironmental proxies: the scale of individual animals' lifetimes. This is nearly as close as possible to an actualistic ecological survey of ungulate behavior during the Last Glacial Period in a setting not analogous to any ecosystem on Earth today.

**Funding Sources** NSF DDRIG; NSF GRFP; Leakey Foundation; Society of Vertebrate Paleontology; Global Change and Sustainability Center; Wilkes Center for Climate Science and Policy

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Technical Session 6: Marine Reptiles (Wednesday, October 18, 2023, 1:45 PM)

## HISTOLOGY AND PALEOPATHOLOGY OF A NEW ELASMOSAUR SKELETON FROM THE PIERRE SHALE OF SOUTHEASTERN MONTANA

O'Keefe, F. R.[1], Armour Smith, Elliott[2], Caroll, Nathan[3], Moore, Sabre[3], Lamm, Ellen-Thérèse[4]

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Recent field work in the *Baculites compressus* zone of the Pierre Shale Group (upper Campanian) of southeastern Montana has yielded the skeleton of a small-bodied elasmosaur. The skeleton comprises an articulated vertebral column missing some anterior cervicals and the tail, a complete shoulder girdle, a weathered skull with preserved jaws, and a left femur. The femur is very small relative to the rest of the skeleton, and is macroscopically pathological, with deep pitting and erosion of the periosteal bone covering the diaphysis. Histological preparation of the femur yielded microanatomy and histology data for further analysis and indicates the abnormal bone surface is pathological rather than an artefact of preservation. The femur has four identifiable growth marks in the periosteum, the inner two of which are significantly remodeled across parts of the bone. The first line is a typical plesiosaur birth line; we interpret the other three annuli as lines of arrested growth, indicating the animal was at least three years old when it died. Remodeling within the bone is extensive, however the primary bone tissue is not completely remodeled into a secondary Haversian system as is typical in adult elasmosaurs. The animal was therefore subadult when it died, making its small size more puzzling. Histologically, the cortex of the femur is abnormally osteoporitic, with extensive erosion rooms lined with fibrolamellar bone throughout. The presence of these rooms in the cortex periphery is unusual. Bone resorption is most common at the center of the shaft in adult plesiosaurs, with a pachyostotic, heavy rind of bone comprising the cortex. The histological preparation also passes through one of the macroscopic lesions on the femoral surface. The lining of this pit is pathological, with disorganized bone containing aberrant vascular tissue. These lesions, the abnormal histology throughout, and the small size of the femur all indicate this limb was probably not functional during life, and that the animal survived for significant time with the injury. Work on the taxonomic affinities of the skeleton is proceeding, but the results of this research indicate that the small femur is pathological, and therefore not of taxonomic utility.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

### AN OSTEOHISTOLOGICAL ANALYSIS OF *TRICERATOPS* POSTORBITAL HORNS

Obuszewski, Kyle[1], Smith, N. Adam[2]

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Ceratopsids are among the most distinctive and well known extinct Cretaceous vertebrates, yet many details regarding the growth and composition of their cranial features are still not fully anatomically described or understood. In particular, striking cranial adornments such as the postorbital horns and parietal-squamosal frill of *Triceratops* experience a series of major morphological and histological shifts throughout ontogeny. Histological examination of these structures can provide clues to the growth strategy of these large, extinct organisms. While previous osteohistological studies have largely focused on the parietal-squamosal frill of *Triceratops*, there are relatively few studies of postorbital horn histology.

Here we present an in-depth osteohistological description of the postorbital horns from a single subadult *Triceratops* specimen and make comparisons with the histological features of the parietal-squamosal frill. Analysis revealed the postorbital horns are composed of an azonal, fibrolamellar bone matrix, which is consistent with rapid and continuous horn growth throughout ontogeny. Primary bone is prevalent throughout the uppermost cortical sections and overlies Haversian tissue. Most vascular canals are longitudinal, and some perforating channels are preserved**.** While the postorbital horns and parietal-squamosal frill are composed of a similar bone matrix, there are major differences in vascularization between the two structures. Additionally, although body size remains a relatively unreliable characteristic for assessing ontogeny, additional histological sampling may provide a means to clarify currently perceived anatomical inconsistencies between adults and putative subadults of *Triceratops*.

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Technical Session 7: Birds (Thursday, October 19, 2023, 8:00 AM)

### *LONGIPTERYX* STOMACH CONTENTS INDICATE THAT MORPHOLOGY DOES NOT ACCURATELY PREDICT DIET IN ENANTIORNITHINES

O'Connor, Jingmai[1], Clark, Alexander[2], Herrera, Fabiany[1], Zhou, Zhonghe[3], Xiaoli, Wang[4], Zheng, Xiaoting[5]

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The rarity of preserved stomach contents in Enantiornithes, the dominant group of terrestrial birds in the Cretaceous, has led to the suggestion that this group primarily fed on soft foods with low preservation potential. This hypothesis contrasts with morphological predictions, which suggest insectivory and vertivory. *Longipteryx* is an unusual Early Cretaceous enantiornithine from the Jehol avifauna with a relatively elongate rostrum and rostrally restricted dentition with enamel that is approximately eight times thicker than in other sampled paravians. Recent statistical analysis of rostral length, body size, and tooth morphology has previously indicated insectivory as the most likely diet. Contrasting with these predictions, two new specimens of *Longipteryx* preserve plant remains within the abdominal cavity interpreted as stomach contents. In one specimen, these remains can be identified as gymnosperm ovules. Their complete and unmacerated preservation and the absence of gastroliths indicate frugivory, similar to *Jeholornis*. This data highlights the limitations of relying on extant data to make ecological predictions in extinct lineages with no living analogues such as toothed birds and pterosaurs.

**Funding Sources** National Natural Science Foundation of China

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Technical Session 15: Paleoecology & Paleoclimatology (Friday, October 20, 2023, 1:45 PM)

**LATEST TRIASSIC AND EARLY JURASSIC CONTINENTAL VERTEBRATE ASSEMBLAGES OF THE CULPEPER RIFT BASIN (VIRGINIA, USA) IN HIGH-RESOLUTION TEMPORAL AND ENVIRONMENTAL PERSPECTIVES**

Olsen, Paul E.[1], Kligman, Ben T.[2], Villari, Joseph[3], Slibeck, Bennett[4], Hughes, Katie[2], Pritchard, Adam C.[5]

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We present a new cyclostratigraphy of Culpeper basin strata post-dating the end Triassic extinction (ETE) placing vertebrate assemblages in a 19kyr-scale astrochronology. In these extremely high accumulation rate, astronomically paced, sedimentary cycles interbedded with Central Atlantic Magmatic Province lavas, fish and rare tetrapod teeth are found in deep-water microlaminated lacustrine strata, with reptile footprints occurring in shallow to ephemeral lake strata. The actinopterygians *Redfieldius*, *Ptycholepis* and a diverse array of *Semionotus* morphotypes, as well as the coelacanth *Diplurus* occur, similar to assemblages in more northern US basins. Reptile teeth, some plausibly dinosaurian, occur in coarser turbidite interbeds. Footprint assemblages are of typical Connecticut Valley aspect including the theropod tracks *Grallator*, *Anchisauripus*, and *Eubrontes* (including *E. giganteus*), the ornithischian ichnite *Anomoepus*, and the crocodylomorph ichnogenus *Batrachopus*. Although, still not well prospected, these strata appear considerably more fossiliferous than their more northern counterparts and may represent environments proximal to high relief shorelines and highlands.

The oldest parts of the sequence, the Mt. Zion Church Basalt and Midland Fm (MF) are latest Rhaetian in age, but younger than the ETE at 201.564±0.016 Ma. The overlying Hickory Grove Basalt and Turkey Run Fm (TF) are within uncertainty of the U-Pb age (201.4 ± 0.2 Ma) of the Rhaetian-Hettangian boundary. The following Sander Basalt and Waterfall Fm (WF) are early Hettangian in age. Despite uncertainty because of poor outcrop, the lacustrine cyclostratigraphy of these units is consistent with that of the more northern basins. Accumulation rates, based on the available outcrop and core, indicate roughly 40m/19kyr for the MF and TF, but higher, closer to 50-60m/19kyr for the WF. The cyclostratigraphy of the MF, TF, and WF appears consistent with that of the more northern US rift basins although accumulation rates are much higher.

The present erosional remnants of rift basins of the US were separate depocenters, but if connected at high stands, the lakes would have been among the largest ever to have existed. This attractive hypothesis may not be testable without coring and detailed sedimentary isotopic analysis to unambiguously establish the astrochronology, identity of marker ashes, and establish the continuity or isolation of high stand water masses.

**Funding Sources** Heising-Simons Foundation, Lamont Climate Center

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Technical Session 14: Crocodylomorphs & Turtles (Friday, October 20, 2023, 1:45 PM)

**USING SURFACE TOPOGRAPHIC ANALYSIS AND PALEOHISTOLOGY TO TRACK THE EVOLUTION OF THE METAPLASTIC LAPPET IN K/PG PAN-TRIONYCHIDS**

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Pan-Trionychids show minimal gross anatomical change across the Cretaceous-Paleogene boundary, but is their bone histology equally unaffected? These soft shelled turtles mineralize the leathery dermis covering their shells into a metaplastic lappet which includes millimeter-scale pits and ridges on the external surface and underlying layers of coarse collagen fiber bundles called the Plywood-Like Structure. Surface Topographic Analysis (STA) and paleohistology sampling were applied to over 200 turtle shells collected across Maastrichtian and Danian deposits, encompassing four formations, 11 degrees of latitude, 12 genera, and a range of sizes and depositional environments.

3D scans of shell ornamentation were captured using a structured light 3D scanner, then quantified with

STA using the MolaR package in R. STA quantifies the complexity, sharpness, and steepness of any surface, including ornamentation morphology. Specimens were paleohistologically sampled at mid-costal and mid-hypoplastron and the resulting thin sections were used to collect measurements from the External Cortex (ECO), the Plywood-Like Structure (PLY), the medullary cavity (MC), the internal cortex (ICO), nutrient foramina (NF), growth marks (GM), and sutures (SU). STA and paleohistology measurements were statistically compared against latitude, stratigraphic position, depositional environment, and formation.

Preliminary data suggests that specimens from different depositional environments show no consistent variance in paleohistology or STA measurements and stratigraphic position imparts negligible variance. High-latitude specimens exhibit greater ECO remodeling and more PLY layers, though comparable longitudinal variance suggests that this correlation is driven by variance across basins as opposed to increased thermoregulatory demand. Older individuals possessed overall thicker shells, wide NF and lower STA values. Carapacial length was not a reliable ontogenetic indicator. Crown plastomenids exhibited greater cortical erosion, along with higher OPCr, DNE and RFI values. There was no systematic variance between carapacial and plastral elements.

Danian Fort Union Formation specimens found just 75cm above the K/Pg boundary showed no discernable deviations from general Danian specimens. Danian turtles overall had thinner shells with more PLY remodeling, relative to their Maastrichtian counterparts, but more anatomical and stratigraphic control is still needed to discern deep time trends.

**Funding Sources** Oklahoma State University, Center for Health Sciences, The Paleontological Society, The Burke Museum, and the LA County Museum of Natural History

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**THE DRAGONS OF CEDAR MOUNTAIN: SHED TEETH INDICATE THE PRESENCE OF ONE OR MORE LARGE ALLOSAUROIDS FROM THE YELLOW CAT MEMBER OF THE CEDAR MOUNTAIN FORMATION**

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Allosauroids were the apex predators in most terrestrial ecosystems during the Early Cretaceous Period. Despite this, the Early Cretaceous Cedar Mountain Formation of eastern Utah has thus far produced only minimal evidence for allosauroids, with the only formally described taxon being *Siats* from the Mussentuchit Member. This lack of known allosaurs is especially apparent in the Yellow Cat Member, where none have been described. However, despite a lack of good material, their presence can be inferred by shed teeth. Here we report on likely allosauroid teeth from three Yellow Cat localities: Grayash (BYU), Blane II (BYU), and Doelling's Bowl (UGS).

All teeth lacked roots and were isolated elements, unassociated with other identifiable allosaur material. Grayash yielded 15 potential allosaur teeth, including teeth from the premaxilla, maxilla, and dentary. The longest measures 63.2 mm in length. The carinae extend to the tip of the teeth and have mid-carina denticle densities of 8-10 per 5 mm. Blane II yielded just one likely allosaur tooth fragment, with a mid-carina denticle density of 13 per 5 mm. Two maxillary teeth from Doelling's Bowl were measured, the longest measuring 91 mm with a mid-carina denticle density of 10 per 5 mm. Teeth from all three localities bear enamel wrinkles more prominent proximal to the carinae.

These animals were likely upwards of 10 m long based on tooth size. The denticle density of the Blane II fragment is within the range of *Acrocanthosaurus* (12.5-17.5), teeth of which have been reported from the younger Ruby Ranch Member. This fragment may be a separate taxon from the other localities, perhaps related to *Acrocanthosaurus*. However, the small sample size prohibits a firm conclusion. The denticle densities of Grayash and Doelling's Bowl are similar to *Carcharodontosaurus* (7.7-10), as well as to each other. However, the Grayash maxillary teeth are proportionally thicker than the Doelling's Bowl teeth, so we cannot yet rule out the possibility of them being separate taxa. The enamel wrinkles present in many of the teeth are consistent with the teeth of carcharodontosaurs, and given their Early Cretaceous age, it is likely that they may indeed be carcharodontosaurian. A thorough morphometric comparison between these teeth and known taxa will hopefully shed light on their exact affinities and may support these teeth as representing the earliest known carcharodontosaurs in North America.

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Romer Prize Session (Thursday, October 19, 2023, 8:00 AM)

**BENEATH THE SURFACE: COMMUNITY STRUCTURE PERSISTS THROUGH END-DEVONIAN MASS EXTINCTION DESPITE MORPHOLOGICAL DISPARITY AMONG EARLY TETRAPODS AND MULTIPLE TERRESTRIALIZATIONS WITHIN THE CROWN GROUP**

Otoo, Benjamin

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There remains an unbridged divide between the ostensibly low-diversity, obligately aquatic, fishlike Devonian tetrapod assemblage and the speciose, ecologically diverse post-Devonian assemblage. Under present hypotheses, the end-Devonian mass extinction (EDME) cleared ecospace, allowing for the origin of the tetrapod crown group, completion of the water-land transition, and start of the modern vertebrate biota. I synthesized data from multiple biological scales to test hypotheses about the functional and ecological context of the origins of post-Devonian tetrapod diversity. My redescription of the postcranium of *Whatcheeria* adds to the disparity and implied ecomorphological diversity of stem tetrapods: it is one of the earliest and most basal large ($\geq$2m) early tetrapods and has walking adaptations coupled with a sensory system characteristic of an aquatic habit. New data from *Whatcheeria* and recent earliest Mississippian discoveries are incorporated into a new phylogenetic matrix. Maximum parsimony analysis supports multiple origins of terrestriality, but only above the crown node. Post-Devonian tetrapods expanded into new regions of morphospace but vacated areas occupied by Devonian tetrapods. Similar morphologies appear in the humeri of a diverse set of aquatic stem and crown tetrapods (*Ossinodus*, *Pederpes*, *Crassigyrinus*, *Baphetes*, *Archegosaurus*); a separate character set is seen in a different array of stem and crown aquatic and terrestrial tetrapods (*Tulerpeton*, *Whatcheeria*, *Greererpeton*, *Proterogyrinus*, *Westlothiana*, *Trimerorhachis*, *Eryops*). These character distributions suggest that the tetrapod stem and early crown represent diverse functional experiments often unrelated to increasing terrestrialization. At the community level, guild occupation and modeled community response to perturbation are near constant through the Frasnian-Famennian and ED extinctions and across marine, nonmarine, and terrestrial settings. The persistence of pre-extinction ecosystem structures despite large-scale faunal turnover and autecological innovations among tetrapods and other vertebrates underscores that the initial diversification of tetrapods occurred in an aquatic context. This work challenges the centrality of terrestrialization to early tetrapod evolution, either at the origin of limbs or of the crown group. Rather, we are now beginning to capture an unrecognized evolutionary radiation it within a time of broader post-Devonian biotic change.

**Funding Sources** Field Museum Armour Fellowship, University of Chicago Hinds Fellowship

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Paleontological Management Poster Session (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**THE WESTERN INTERIOR SEAWAY BY FLAT-BOTTOMED BOAT: SURVEY AND SALVAGE OF US ARMY CORPS OF ENGINEERS LAND IN SOUTH DAKOTA, USA**

Pagnac, Darrin C.

Geology, South Dakota Mines, Rapid City, South Dakota, United States

The U.S. Army Corps of Engineers (USACE) is the branch of the U.S. Army (Department of Defense) that manages navigable inland waterways. As one of the world's largest public engineering management endeavors, they operate and maintain over 12,000 miles of inland shoreline; 926 coastlines, Great Lakes, and inland harbors; 383 major lakes and reservoirs; and 609 dams and spillways. This coverage translates to thousands of miles of underutilized waterfront exposure with paleontological potential. South Dakota Mines has conducted annual survey and salvage with the USACE along Lake Francis Case in central South Dakota for over twenty-five years, documenting and salvaging hundreds of specimens from the upper Cretaceous Niobrara and Pierre formations. In the past ten years, annual surveys have resulted in the documentation of over 600 noteworthy specimens and salvage of over two dozen. Osteichthyes is the most encountered taxon, followed by Mosasauridae. The Niobrara Formation is the most productive unit, followed by the Burning Brule Member of the Pierre

Formation. Compilation of these data has resulted in numerous abstracts and publications and is a major source of material for theses in South Dakota Mines' graduate programs. Students also gain invaluable experience directly participating in annual surveys through our field paleontology program. Working along these waterways can pose unique challenges. Access to outcrops has necessitated approach by boat, posing numerous safety and logistical challenges. Fluctuating water levels can limit access to outcrops. Because the USACE maintains water levels and adjusts dam releases constantly, a detailed review of water management plans and pre-field scheduling is critical. Additionally, the sheer volume of productive outcrop can be daunting. Permitting is unconventional, as the USACE has no dedicated division of paleontology; as such, salvage permitting is granted through the Antiquities Act. Despite these challenges, South Dakota Mines has had a fruitful, multi-decade collaboration with the USACE, and has gained access to significant specimens and data. Conversely, because the USACE can suffer from a poor public image, as they are often the scapegoat for flooding, the promotion of exciting and valuable fossil resources can enhance their public image. The USACE remains an underutilized partner in ongoing fossil resource management efforts and should be included under PRPA legislation.

**Funding Sources** US Army Corps of Engineers, Lake Francis Case/Fort Randall Dam

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

## COMPARATIVE MANDIBULAR MORPHOLOGY OF EXTINCT AND EXTANT CROWN PINNIPEDS

Palmer, Stephanie M.[1], Rule, James P.[2], Cooke, Siobhan B.[1]

[1]Functional Anatomy and Evolution, Johns Hopkins University, Baltimore, Maryland, United States, [2]Department of Life Sciences, London Natural History Museum, London, United Kingdom

Pinnipedia, a group of secondarily aquatic vertebrates, comprises three extant clades: true seals (Phocidae), eared seals (Otariidae), and walruses (Odobenidae). Despite their shared semi-aquatic affinities, each clade is morphologically distinct and displays various feeding strategies. However, the evolution of these mandibular morphologies has been mostly underexplored. In this study, we use three-dimensional landmark based geometric morphometrics and comparative phylogenetic methods to quantify the mandibular morphology of crown pinnipeds. Our sample consisted of one crown odobenid, 6 stem odobenids, 12 crown otariids, two stem otariids, 13 extant phocids, 5 extinct phocids, and two stem Otarioidea (Desmatophocidae). Generalized Procrustes analysis, principal component analysis, and ancestral state estimation were performed to remove influence of size, rotation, and translation from landmarks, and visualize shape differences between species through time. Analyses were performed in R using the packages geomorph, Morpho, and phytools.

PCs 1-13 explained approximately 95% of the variation, with PC1 and PC2 representing a large portion. PC1 (31.58% of variation) encompassed differences in the dorsoventral depth of the mandibular corpus at the symphysis; shifts of the postcanine toothrow relative to the mandibular ramus; and shifts of the coronoid process relative to the mandibular condyle. These characters appear to separate Phocidae from Otarioidea across PC1. PC2 (17.93% of variation) encompassed differences in the dorso-ventral depth of the mandibular symphysis and ramus; shifts in the length and position of the postcanine toothrow; and shifts in the position of the anterior margin of the masseteric fossa relative to the mandibular ramus. PC2 separated suction/filter-feeding taxa (*Erignathus, Lobodon, Osodobenus,* and *Odobenus*) from non-suction/filter-feeding taxa. PC2 also captures a transition along the Odobenid lineage from otariid-like to odobenid-like morphology. Desmatophocids were similar to Otarioidea in morphology along both PC1 and PC2. Ancestral state estimations show an intermediate ancestral mandibular morphology for crown Pinnipeds for both PC1 and PC2.

Overall, these results highlight differing morphotypes separating Phocidae and Otarioidea, a distinct morphology of suction/filter-feeders, the morphological evolution in odobenids from otariid-like to odobenid-like, and similarity between Desmatophocids and Otarioidea.

**Funding Sources** The Los Angeles County Natural History Museum (SP), Australian Government RTP, Robert Blackwood scholarship, Monash University, and a UKRI Fellowship (EP/X021238/1) (JR).

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**TRENDS IN CRANIODENTAL MORPHOLOGY IN THE AMERICAN MINK (*NEOGALE VISON*)**

Pamfilie, Alexandra M., Byran, Averill, Vitek, Natasha S.

Ecology and Evolution, Stony Brook University, Stony Brook, New York, United States

The fossil record has intrinsic challenges in assessing the partitioning of intraspecific morphological variation. These challenges are somewhat alleviated when studying more recent fossil assemblages that can be compared more directly to living populations. Comparing the morphologies found in Quaternary assemblages to those found in living populations is useful for understanding the patterns produced by microevolutionary processes. These comparisons can also be useful in case studies of extant species and can highlight range shifts and changes in average morphology as part of the species' natural history. The American mink (*Neogale vison*) has known fossil occurrences across much of its North American range, providing an opportunity to study microevolutionary processes on a large geographic scale in the fossil record. Natural history literature describes patterns of morphological variation among extant populations from Alaska to Florida; paleontological literature reports hundreds of fossil occurrences from the Irvingtonian to the present across this range. Based on this, there is spatial morphological variation within *N. vison* that may be detectable in the fossil record and may also be used to detect within-species range shifts and microevolutionary dynamics. As a first step towards this aim, we quantified craniodental morphological variation among mink from the Pacific Northwest, Alaska, and British Columbia. When comparing between sexes, male mink had longer crania, but we found no other significant sexual dimorphism. When comparing putative subpopulations, individuals from the mainland were morphologically different from island individuals, particularly those originating from the Alexander Archipelago. The comparison of these results to fossil specimens from this range, as well as the addition of fossil and extant specimens from the eastern United States, will provide further opportunities to directly compare individuals living in similar ranges from the last million years. These results reflect observations made in the literature over the last two centuries but also have the potential to provide more specific insights into the population dynamics and unique local variation in *N. vison*. Further study and analysis will inform morphological trends within a putative species over broad spatial scales.

**Funding Sources** G. Williams Award (Department of Ecology and Evolution, Stony Brook University)

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Technical Session 2: Early Mammals & Carnivora (Wednesday, October 18, 2023, 8:00 AM)

**JURASSIC FOSSIL JUVENILE MAMMALIAFORM FROM SCOTLAND PROVIDES LIFE HISTORY CASE STUDY IN EARLY MAMMALS**

Panciroli, Elsa[1], Benson, Roger[2], Fernandez, Vincent[3], Fraser, Nicholas[4], Humpage, Matt[5], Luo, Zhe-Xi[6], Newham, Elis[7], Walsh, Stig[4]

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Understanding the origin and evolution of mammalian life history traits is one of the most significant areas of mammal paleontology. Among living mammals, species of smaller body mass generally develop relatively quickly, mature younger, have larger litters and live shorter lives than those with larger body masses. Studying the emergence of such traits in the Mesozoic requires fossil evidence from early mammaliaforms, the predecessors of living mammals. These predecessors had very small body masses (mostly <100g) and diphyodont tooth replacement, but also appear to have exhibited long life spans and slower growth rates compared to small-bodied mammals today. The paucity of juvenile fossil mammaliaforms has impeded our understanding of evolution of life history traits in early mammals as a whole. We utilize the rare skeletons of a newly discovered juvenile (~40% complete) and adult (~95% complete) docodontan mammaliaform, *Krusatodon kirtlingtonensis* from the Middle Jurassic of Scotland, to examine the timing and schedule of tooth eruption and growth in this early diverging group of mammaliaforms.

The fossil skeletons were found in the Bathonian Kilmaluag Formation, at the Elgol Coast site of special scientific interest (SSSI), in the Isle of Skye (An t-Eilean Sgitheanach). This site is known for its exceptional preservation of microvertebrates with minimal deformation. For the first time, the two skeletal fossils of *Krusatodon* make it feasible to estimate the sequence of tooth replacement, body size and chronological age in annual cycles. We used phase-contrast synchrotron X-ray micro-computed tomography to examine cementum increments along the tooth row in the juvenile, which was in the process of replacing its deciduous dentition, and LAGS (lines of arrested growth) in the dentary. These showed that although the relative pattern of tooth eruption and replacement in relation to body size in *Krusatodon* is similar to modern mammals, eruption and replacement was significantly delayed in terms of the absolute chronological age at which this occurred. The estimated age of the juvenile and timing of tooth replacement suggests a significantly slower growth-rate than living mammals of similar body mass. The mixture of plesiomorphic and modern traits exhibited by this fossil mammaliaform may provide a representative model for ancestral mammal development, indicating the stochastic emergence of such traits, beginning in some lineages at least by the Early Jurassic.

**Funding Sources** The Leverhulme Trust, the John Fell Fund, EPA Cephalosporin Fellowship, and Natural Environment Research Council (NE/L002558/1).

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Preparators' Poster Session (Thursday, October 19, 2023, 4:30 - 6:30 PM)

### AUGMENTING ANATOMICAL RECONSTRUCTION OF VERTEBRATE FOSSIL CRANIA - A CASE STUDY OF 3D PRINTING FOR RESEARCH, OUTREACH, AND EXHIBITS

Panigot, Eldon[1], Burns, Emily[1], Petermann, Holger[1], Lyson, Tyler[1], Rubidge, Bruce S.[2], Bever, Gabriel S.[3]

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In-situ fossils are rarely preserved in optimal conditions. They are usually broken, disarticulated, and distorted. However, understanding anatomy and establishing systematic relationships is best done on undistorted remains. This requires that fossils are restored to their life-like condition, or reconstructed. Traditionally, we have relied on line drawings to present an undistorted interpretation of fossil remains in 2D and we have used plaster, epoxy, and other materials to create 3D interpretations of missing anatomical detail. Structured-light/Laser surface or CT scanning permit creation of a three-dimensional (3D) model of a fossil which then can be sculpted and reassembled into an approximation of the in-life condition using animation software such as Blender or Maya. We used another steadily improving technology, 3D printing or additive manufacturing, to 3D print individual elements, as well as entire crania. The prints, in addition to the digital models, were then used to reconstruct the skulls of two extinct reptiles that showed some degree of taphonomic and diagenetic distortion. We found that 3D printing these models aids in the reconstruction process as a method for testing topological hypotheses through manipulating individual elements scaled up or down for ease of use. The finalized models can be added to existing and in-development exhibits and allow museums to quickly create stand-ins for specimens that have been removed for study or sent out on loan. These models also improve outreach efforts by adding tactile elements to show-and-tell and educational programs and aid in visibly demonstrating 3D damage to fossils. While the additional step of 3D printing does create storage and monetary concerns, we have found that the benefits far outweigh the drawbacks.

**Funding Sources** National Science Foundation, Denver Museum of Nature and Science

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Technical Session 10: Euarchontoglires & Xenarthra (Friday, October 20, 2023, 8:00 AM)

### PALEOMETRY APPLIED TO TAPHONOMY: EVIDENCE FOR AN ANTHROPOGENICALLY MODIFIED GROUND SLOTH TOOTH FROM THE LATE PLEISTOCENE OF THE BRAZILIAN INTERTROPICAL REGION

Pansani, Thais R.[1], Dantas, Mário[2], Asevedo, Lidiane[2], de Araújo-Júnior, Hermínio I.[3], Gueriau, Pierre[4], Thoury, Mathieu[5], Bertrand, Loïc[6], Behrensmeyer, Anna K.[7], Pobiner, Briana[8]

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Evidence of human interaction with the Pleistocene megafauna in South America is scarce and often controversial. Distinguishing anthropogenic marks from other taphonomic traces in zooarchaeological and paleontological contexts is a complex task, mainly because of the subjectivity of interpretation by different taphonomists as well as issues of equifinality. Through six state-of-the-art multidisciplinary techniques, we investigated a fragmentary tooth assigned to the extinct giant ground sloth *Eremotherium laurillardi* from the Brazilian Intertropical Region - BIR (Sergipe State), previously described as anthropically modified. This earlier claim remained disputable mainly because of the lack of meticulous investigation and detailed information regarding the tooth's taphonomic context. Here, we acquired Stereomicroscope and Scanning Electron Microscopy (SEM) images supplemented by Energy Dispersive Spectroscopy (EDS), Photoluminescence (PL), synchrotron-based X-Ray Fluorescence (SR-XRF), and synchrotron-based micro-computed tomography (SR-μCT) analyses, to finely characterize preserved surface modifications from the macro- to the micro-scale. The combination of these techniques allows us to clearly distinguish between anthropic marks and other taphonomic signatures (i.e., root damage, bioerosion, and trample marks) on the internal view of the tooth, and histological microstructures in the lateral view. The fragmentary tooth is intentionally shaped, and remarkably distinct in comparison with the natural giant ground sloth tooth. The proposed anthropic modification consists of superficial elongated scratches multi-oriented along the internal polished surface of the tooth and sets of smaller and deeper parallel linear marks with similar sizes, widths, and depths in the internal view of the tooth surface, predominantly oriented to the curvature of the tooth's lateral edges. EDS and XRF data reveal the tooth's elemental distribution, where Al, Si, Fe, and Rb are enriched in the exposed histological microstructures. The overprint of non-anthropic taphonomic traces on the anthropic marks, distinguishable by PL, leads us to conclude that this tooth was modified before its final burial and fossilization. In sum, we corroborate the anthropic modification of a giant ground sloth tooth in the BIR during the late Pleistocene (~13,800 Cal years BP) and demonstrate the potential of using paleometric analytic techniques in the investigation of taphonomic questions.

**Funding Sources** Conselho Nacional de Desenvolvimento Científico e Tecnológico, Coordenação de Aperfeiçoamento de Pessoal de Nível Superior, The Smithsonian Institution Fellowship

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

## POPULATION-LEVEL DIETARY PROXIES DOCUMENT THE FORAGING BEHAVIOR OF FLAT-HEADED PECCARIES (*PLATYGONUS COMPRESSUS*) DURING SEASONAL DENNING IN BAT CAVE (OZARK PLATEAU, PULASKI CO., MO, USA)

Pardi, Melissa I.[1], Woodruff, Aaron[2], Mueller - Filipes, Elsa[3], DeSantis, Larisa[3]

[1]Research and Collections Center, Illinois State Museum, Springfield, Illinois, United States, [2]Vertebrate Paleontology, Florida Museum of Natural History, Gainesville, Florida, United States, [3]Biological Sciences, Vanderbilt University, Nashville, Tennessee, United States

Flat-headed peccaries (*Platygonus compressus*) from Bat Cave (Ozark Plateau, Pulaski Co., MO, USA) present an opportunity to explore population-level behavior in an extinct herbivore. As a species, *P. compressus* exhibits a varied diet that typically consists of C3 browse but often includes mixed-feeding. A previously published demographic assessment identified non-overlapping age categories in *P. compressus* from Bat Cave, suggesting synchronous, seasonal denning behavior. If these animals are making general use of resources, we expect dietary proxies to reflect the forage present in the season peccaries were denning in the cave.

We assessed dietary behavior at the time of denning at Bat Cave through dental microwear texture analysis (DMTA) and analyzed three microwear parameters: anisotropy (*epLsar*), complexity (*Asfc*), and textural fill volume (*Tfv*). High resolution molds were taken of molars from distinct individuals that had been aged in a prior study. Molds were cast and scanned at Vanderbilt University using white light confocal microscopy and scale-sensitive fractal analysis of tooth wear facets. Previously published DMTA values from *Platygonus* spp. from other localities were also compared with the Bat Cave sample.

The microwear sample from Bat Cave is not significantly different from other published *P. compressus* values at other localities in terms of *Asfc* and *epLsar* but has significantly lower *Tfv* values. There is a significant positive linear relationship between age and *Tfv* ($p = 0.004$) among individuals from Bat Cave that warrants further investigation. It is possible that larger, deeper microwear features may persist over time and higher *Tfv* values in older individuals may represent a time averaged accumulation of these features over the life of the animal.

We predicted that if *P. compressus* from Bat Cave were engaging in seasonal denning behavior, then values of *Asfc* and *epLsar* would be more constrained at the local level than across the species. Instead, we found high variation in local values, which suggests this assemblage is represented by individuals consuming disparate diets. These animals may in fact be making general use of seasonally available forage; however, it is unclear how much time averaging is represented in this assemblage. Stable isotope analysis of $\delta^{13}C_{enamel}$ may reveal the relative use of C3 and C4 resources and analysis of $\delta^{18}O_{enamel}$ may help characterize the environmental conditions these individuals were living in.

**Funding Sources** Illinois State Museum, University of Florida, Vanderbilt University, and the National Science Foundation

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Technical Session 18: Synapsids (Saturday, October 21, 2023, 8:00 AM)

## PARTIAL AND COMPLETE SECONDARY PALATES OF SCINCID LIZARDS: AN ANALOG FOR NON-MAMMALIAN SYNAPSIDS?

Pardo, Jason, Angielczyk, Kenneth D.
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A complete bony shelf creating a nasopharyngeal passage distinct from the oropharynx is characteristic of several important vertebrate groups, including modern mammals and a range of other fossil and living amniote lineages. Although a complete secondary palate plays multiple roles in feeding, respiration, and thermoregulation, we understand relatively little about the anatomy and function of incomplete secondary palates and the selective pressures that drive parallel acquisitions of the secondary palate within diversifications such as Therapsida. To this end, we surveyed skeletal and soft-tissue anatomy of the secondary palate in a modern lizard diversification, the Scincidae. The scincid secondary palate is comprised of a ventral shelf of the palatine beginning at the posterolateral margin of the choana and projecting posteriorly towards the suture with the pterygoid. The medial extent of this shelf varies across taxa, with the shelf covering approximately 60% of the width of the palate in most taxa but forming a long midline suture in a subset of species distributed across multiple clades. In extreme cases with broad phylogenetic distribution, the maxilla participates in the anteriormost portion of the palatal shelf, underlying the lateral and posterior portion of the choanal cleft. In species where the palatal shelves do not reach the midline, the soft palate extends medially beyond the extent of the bony palate to partially or completely close the secondary palate at the midline. Interestingly, in some taxa, such as *Tiliqua* and *Trachylepis*, broad lateral flanges of the vomer underlying the vomeronasal organ obstruct the anterior portion of the ancestral choana, fully obstructing any flow from the nasopharynx into the oropharynx until the basisphenoid region. Secondary palate extent is evolutionarily labile, with parallel originations of a complete bony palate in nearly every scincid subfamily. If scincid palates can be considered an effective analog for the therapsid condition, this may indicate a single early origin of a complete nasopharynx with extensive soft palate in most if not all eutheriodonts, with later parallel derivations of the complete bony secondary palate. Further, the potential for the vomer to contribute to closure of the choana should be considered when interpreting patterns of airflow through the nasal passages of even early therapsids.

**Funding Sources** JDP is supported by NSERC-CRSNG Banting Fellowship BPF-181636

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Technical Session 2: Early Mammals & Carnivora (Wednesday, October 18, 2023, 8:00 AM)

**THE CHANGING MENU OF SABERTOOTH CATS: DIETARY ECOLOGY OF *SMILODON* DURING GLACIAL AND INTERGLACIAL PERIODS OF THE PLEISTOCENE**

Pardo, Justin R., DeSantis, Larisa

Biological Sciences, Vanderbilt University, Nashville, Tennessee, United States

Climate change, including glacial cooling and interglacial warming can influence dietary behavior, potentially including prey preferences and the degree of carcass utilization. In Florida during the Pleistocene, the diet of *Smilodon gracilis*, a more gracile saber-toothed cat, shifted prey-preference depending on whether it lived during a glacial or interglacial period. In this study, we further investigate the dietary behavior of *S. gracilis* that lived in Florida during glacial and interglacial periods by expanding the paleodietary analysis to include dental microwear texture analyses (DMTA). Specifically, DMTA captures dietary behavior in the final days to weeks of these mammals' lives. We compared *S. gracilis* dental microwear from a glacial site (Inglis 1A, n=8) and an interglacial site (Leisey Shell Pit 1A, n=10). While differences in Asfc values only approach significance (p=0.091) between these sites, the mean Asfc values at Inglis 1A (6.015 +/- 4.530 SD) is nearly double that of the mean at Leisey Shell Pit 1A (3.052 +/- 1.530 SD), potentially indicative of increased carcass utilization during glacial periods. Data obtained in this study are consistent with a previously documented pattern in *S. fatalis*, indicating higher Asfc values during pit accumulations in glacial periods as compared to interglacial periods at Rancho La Brea. While *S. fatalis* and *S. gracilis* had indistinguishable Asfc values from one another at the species level, the Asfc values of *S. gracilis* individuals from glacial periods were indistinguishable from the glacial period *S. fatalis* individuals (Pits 13 and 77) and significantly higher than Asfc values of *S. fatalis* individuals from interglacial periods (Pits 3 and 61/67). The converse is also true of *S. fatalis* and *S. gracilis* from interglacial periods that were found to be indistinguishable from one another but did have significantly lower Asfc values than *S. fatalis* individuals from glacial periods. This suggests that during glacial periods, both *S. fatalis* and *S. gracilis* species may have experienced ecological pressures of reduced prey availability and increased competition, which potentially resulted in a higher degree of bone consumption. Our findings provide a more comprehensive understanding of the dietary habits of *S. gracilis*, an apex predator in the ancient Floridian landscape. The results of this study demonstrate the sensitivity of top predators to abiotic climate change.

**Funding Sources** National Science Foundation; Vanderbilt University

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Paleontological Management Poster Session (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**BUILDING A TRIASSIC PARK: FORMULATING A CREDIBLE SCIENTIFIC RESEARCH AND OUTREACH PROGRAM FOR PALEONTOLOGY IN A U.S. NATIONAL PARK**

Parker, William G., Smith, Matthew E., Marsh, Adam

Department of Science and Resource Management, Petrified Forest National Park, Petrified Forest, Arizona, United States

Although the United States often sets aside important scientific and historical sites as National Monuments and Parks for protection and the enjoyment of the public, the full scientific significance of the sites are often not completely recognized or evaluated. Several sites in the U.S. have been set aside specifically for paleontology, the earliest of which is Petrified Forest National Park (PEFO) in northeastern Arizona that protects fossils of Late Triassic age. Established in 1906 to protect the 'mineralized remains of Mesozoic forests", for most of its history park management focused almost singularly on keeping visitors from removing pieces of the petrified wood common in specific sites along the road, rather than on the research and education potential of the full extent of the 20-million year interval of Late Triassic terrestrial ecosystems preserved as fossils within the park boundary. Although it was recognized early on that other plant fossils as well as vertebrate animals were also preserved, little effort was made to fully understand the significance of these occurrences. Research in the 1980s (primarily by non-NPS research teams) raised the profile of the vertebrate animals to a certain extent, including the addition of four mounted skeletons for public exhibit, but the significance of the park for Triassic paleontology was still understated. In 2002 the park added its first full-time dedicated paleontologist with the goal of increasing the understanding of life at equatorial Pangaea during the Late Triassic. The idea was that not only should PEFO protect these fossils, it should also create educational and research programs to make the fossils of the park some of the best studied in the world. PEFO's "Triassic Park" was created with the overarching goal of serving as a world class research program that also invites other researchers to answer questions within the park. This goal has been realized by incrementally adding fossil preparation facilities, creating exhibits and interpretive waysides, hiring a permanent curator and other paleontology and museum staff, attracting and coordinating outside research groups, and synthesizing all of this work to make the park the place to learn about life during this critical period of Earth's history. Today PEFO is a leader in NPS paleontology and Triassic research, demonstrating the importance of national parks as scientific and educational workshops similar to any non-federal natural history museum.

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Technical Session 11: Archosaurs (Friday, October 20, 2023, 8:00 AM)

**A PARTIAL PTEROSAUR EGG CONTAINING AN EMBRYONIC SKULL, NECK, SHOULDER, PARTIAL FORELIMB, AND SOME FOSSILIZED SOFT TISSUES FROM THE EARLY CRETACEOUS CLOVERLY FORMATION OF CENTRAL MONTANA**

Parsons, William L., Parsons, Kristen M.

The Gow School, South Wales, New York, United States

A small fragment of two fused pterosaur eggs was recovered from an Early Cretaceous Cloverly Formation site in central Montana. A significant amount of eggshell was recovered as well. This fragment was recovered from a site within an 8.23-meter-deep layer of bentonite below the Unit VI stratum of the Early Cretaceous Cloverly Formation in central Montana. This bentonite layer is associated with river channel deposits. Both egg fragments exhibit some bone and skin fragments. One egg fragment contains a relatively intact embryonic skull. The skull is lying with its right lateral side exposed. The lower jaw has been disarticulated and re-positioned such that the tip of the premaxilla is almost in contact with the mesial end of the lower jaw. The dorsal surface of the lower jaw is partially exposed through the egg matrix. The cross-sectional width of the egg is 21.82 mm. The length of the skull is 4.53 mm, which makes it one of the smallest skulls to have ever been recovered from Mesozoic strata. Given the size of the skull in comparison to the size of the internal matrix of the egg, this embryo was still in an early stage of development. Still, the morphometric ratios that can be determined within the cranium are comparable to at least some adult pterosaurs. Above the skull, there is a remnant of flat tissue associated with wing bones. This flat tissue carries the imprint of a fine hair-like patterned covering of the possible wing skin. The more distal end of the cranium and the neck are covered with fossilized skin. The skin appears to possess a fine scale-like patterning. Other isolated patches of skin can be found throughout the egg matrix. Other than the removal of the soft mud-like sedimentary materials, given the incredibly delicate nature of this specimen, very little prepping has been conducted. The remarkable quality of this preservation of soft tissues is due to a combination of immediate burial in heated, sterile volcanic ash, and although no longer radioactive, it is probable that this bentonite layer was radioactive at the time of burial. These discoveries offer the potential to further soft tissue/molecular research, as well as providing further evidence that will enhance our knowledge of the earliest ontogenetic stages of development within the closely related members of the clade of pterosaurs that includes this taxon.

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Technical Session 11: Archosaurs (Friday, October 20, 2023, 8:00 AM)

**THE POTENTIAL OF UNASSUMING FOSSILS: ASSESSING THE TAXONOMIC UTILITY OF OSTEODERM MORPHOLOGY.**

Patellos, Emily[1], Smith, Nathan D.[2], Bottjer, David[1]

[1]Earth Sciences, University of Southern California Dana and David Dornsife College of Letters Arts and Sciences, Los Angeles, California, United States, [2]Natural History Museum of Los Angeles County, Los Angeles, California, United States

Preservation bias plays a major role in our understanding of the geologic past. Robust skeletal elements have more fossilization potential, which can lead to an over-representation of these elements in the rock record. Osteoderms (bony plates found in the skin of multiple vertebrate groups) are one such example—they are found in abundance in the fossil record but are considered less taxonomically useful in isolation compared to other skeletal elements. The degree to which osteoderm morphology is influenced by evolutionary history versus non-phylogenetic factors (e.g., ecology, function, body-size) is not well known. For this study, a survey of osteoderm morphology is conducted using simple linear measurements (e.g., length, width, thickness) to describe overall osteoderm shape within Archosauria. Archosaurs (and outgroups in Archosauromorpha) were chosen for this study in part due to the dichotomy in osteoderm presence between pseudosuchian and avemetatarsalian archosaurs. Most lineages within Pseudosuchia retained osteoderms from the ancestral archosaur condition, whereas the avemetatarsalian branch lost osteoderms early in their evolutionary history, only to re-evolve them later in several clades. Taxa surveyed include isolated osteoderms from the earliest non-crocodylomorph pseudosuchians, and non-archosaurian Archosauromorpha— specifically the aetosaurs *Stagonolepis* (14), *Scutarx* (2), *Calyptosuchus* (1) and *Paratypothroax* (5), the aetosauriform *Revueltosaurus* (28), the phytosaur *Leptosuchus* (9), and the archosauriform *Vancleavea* (10), as well as a number of unknown phytosaur (47) and aetosaur (2) taxa. Results show that osteoderm morphologies exhibit the most variance within their anterior-posterior length, followed by the anterior-posterior length of the osteoderm keel. Anterior-posterior length is relatively conserved within clades, whereas lateral width is more homoplastic. Aetosaurian and phytosaurian osteoderms take up a large area of morphospace, though rarely overlap. *Revueltosaurus* and *Vancleavea* osteoderms take up a much smaller morphospace but sit between and span both aetosaur and phytosaur morphospace. Expanding this dataset crownward within the evolutionary tree of Archosauria is necessary to determine overall levels of phylogenetic signal in osteoderm morphology, and the accuracy and limits of taxonomic identification from isolated or fragmentary osteoderms.

**Funding Sources** The Earth Sciences Department at the University of Southern California; Natural History Museum of Los Angeles County; SEPM Society of Sedimentary Geology.

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Colbert Poster Prize Session

**DENTAL ENAMEL PROTEOMES FROM THE HOLOCENE THROUGH TO THE EARLY MIOCENE REVEAL PATTERNS OF ANCIENT PROTEIN PRESERVATION AND DEGRADATION**

Paterson, Ryan S.[1], Mackie, Meaghan[1], Patramanis, Ioannis[1], Strange, Andreas Christian[1], Fraser, Danielle[2], Rybczynski, Natalia[3], MacPhee, Ross[4], Demeter, Fabrice[1], Cappellini, Enrico[1]

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Paleoproteomics has revealed insights into the evolution of several extinct taxa but has yet to be widely-adopted for deep-time applications of phylogeny or sex estimation, even for fossils from depositional contexts where ancient proteins would be expected to survive. Deep-time analyses are often restricted to a single taxonomic group or paleontological site, making it difficult to draw general patterns on the preservation of ancient proteomes and their utility. However, recent advances in streamlining and simplification of laboratory and analytical workflows have made larger scale analyses feasible. Here, we present the first large-scale analysis of ancient dental proteomes from across a wide taxonomic sampling of fossil mammals, covering disparate geographic regions and time periods, stretching from the recent archaeological record to the Early Miocene. Laboratory workflows targeted peptides bound within the mineralized dental enamel. These methods were successful in recovering phylogenetically-informative ancient protein sequences from a variety of depositional contexts, including exceptionally rich dental proteomes from high latitude Pliocene and Miocene sites in Canada’s High Arctic. Conversely, Miocene sites situated closer to the equator preserved only peptides covering highly-conserved sequence regions.

Proteomic characterization of such differentially-preserved fossil proteomes permits the identification of a novel suite of degradation markers necessary for establishing authenticity of ancient protein sequences. While deamidation is the most widely-used measure of assessing authenticity in ancient samples, deamidation levels plateau relatively quickly in Holocene samples. The present research identifies an alternative post translational modification (PTM) – the conversion of arginine to ornithine (Arg->Orn) – that serves as a more appropriate tool for assessing proteome degradation in deep-time palaeoproteomics. Recent archaeological samples display negligible rates of Arg->Orn, while the most ancient samples analyzed display nearly complete occupancy of this PTM. In addition to arginine, glutamine, and asparagine, several other amino acids are almost always modified in the most ancient samples. This suite of modifications complicates data analysis, but serves as a necessary criterion for demonstrating authenticity, as proteins are recovered from increasingly ancient contexts.

**Funding Sources** This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement (No. 861389).

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Technical Session 11: Archosaurs (Friday, October 20, 2023, 8:00 AM)

## THE OPAQUE MIDDLE TRIASSIC ASSEMBLAGES OF THE LUANGWA BASIN (ZAMBIA), WITH A NEW ARMORED ARCHOSAUR OCCURRENCE

Peecook, Brandon R.[1], Angielczyk, Kenneth D.[2], Museba, Joseph[3], Nesbitt, Sterling J.[4], Sidor, Christian A.[5], Smith, Roger M.[6], Tolan, Stephen[7], Viglietti, Pia[2], Whitney, Megan[8]

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The first half of the Triassic Period saw the first appearance and rapid diversification of a number of vertebrate clades foundational to the biodiversity of the Mesozoic Era and today's communities. Archosauromorpha are known from the Lopingian, but the earliest body fossils of crown Archosauria (Crocodilia + Aves) are restricted to the Triassic. Crocodile-line archosaur body fossils appear in the Early Triassic, but the earliest known bird-line archosaur body fossils are not as well constrained. The Red Marl (= "upper Ntawere") Formation of the Luangwa Basin, Zambia, and Lifua Member of the Manda Beds of the Ruhuhu Basin, Tanzania have both produced dinosauriforms (*Lutungutali*, *Asilisaurus*, *Nyasasaurus*), which until recently were considered lower Middle Triassic (Anisian) based on defunct long-range vertebrate biostratigraphy. Continued fieldwork, and comparison to radiometrically dated sequences in South America, have pushed the likely ages of these fossils into the late Middle Triassic (Ladinian), possibly even the early Late Triassic (Carnian).

Between 2009-2018 our team, and colleagues, had documented two vertebrate assemblages in the Ntawere (cynognathian cynodonts, dicynodonts) and Red Marl (fishes, temnospondyls, archosaurs, trirachodontid and traversodontid cynodonts, stahleckeriid dicynodonts) formations. The archosaurs include enormous loricatan predators and the oldest known shuvosaurid poposauroids from the crocodile-line, and silesaurids like *Lutungutali* and some large-bodied (femur length > 35cm) individuals from the bird-line.

During fieldwork in 2018 and 2019 we made preliminary collections of a new highest Red Marl assemblage in the Luangwa Basin with biostratigraphic ties via stenaulorhynchine rhynchosaurs to the Lifua Member, and to two South American assemblages tied to the Middle-Late Triassic boundary: the *Dinodontosaurus* Assemblage Zone (AZ), Santa Maria Formation (Brazil) and the *Tarjadia* AZ, Chañares Formation (Argentina). Alongside stenaulorhynchines, silesaurids, stahleckeriids, and traversodontids, we report the first remains of an armored archosaur from Zambia based on an ornamented osteoderm with a posteriorly pointed keel, similar to aetosauriforms.

Taken together, this new assemblage enhances assemblage similarity with other basins, and allows us to reconstruct a temporal scheme within the Luangwa Basin that likely spans much of the Middle Triassic and can be tested with radiometric dating.

**Funding Sources** Idaho Museum of Natural History; National Geographic Society (8571-08; 8962-11); NSF (EAR-1337569; EAR-1337291)

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Colbert Poster Prize Session

assemblages. The resulting analysis provides new insights on community changes and land use patterns during this integral period of hominin evolution.

**Funding Sources** The Leakey Foundation. Indiana University Bloomington Department of Earth and Atmospheric Sciences

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

## DEMOGRAPHIC DIVERSITY AMONG JOURNAL OF VERTEBRATE PALEONTOLOGY FIRST AUTHORS BASED ON PALEONTOLOGICAL SUBFIELD

Peng, Amanda W., Hopkins, Samantha

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In recent years, many fields have recognized that there are biases present in all levels of academia, which affect everyone from students pursuing undergraduate degrees up to those in the professoriate. The field of paleontology is not immune to these effects, and the Earth sciences at large continue to be one of the least gender and race-diverse science fields. While many studies have shown this on a broad scale, the narrower field of paleontology has not received similar attention. Few data are available on the demographics of academic vertebrate paleontologists, and such data would be invaluable for the purposes of policy-making, planning, and general knowledge for universities and discipline-specific societies. In this study, we examine whether there are demographic differences among the authors who publish in various paleontological subfields. Because subfields in paleontology are frequently separated along taxonomic lines, we consider the broad fields of mammal and dinosaur paleontology. We address this through an investigation of the demographic structure of first authors with publications in the Journal of Vertebrate Paleontology (JVP). We perform analyses which predict gender and race using given and last names based on historical data, including Social Security and voter registration data. We find that first authors of publications concerning the topics of mammals and dinosaurs are overwhelmingly (75.4%-82%) male, while female authors make up a much smaller proportion in both subject categories (18-24.6%). Authors estimated to be White also make up a majority of the pool, authoring about 80% of

publications, while predicted Hispanic, Black, Asian, and Native American authors make up 6.6-8.2%, 1.2-1.8%, 9.8-10.9%, and 0% of authorship, respectively. For both race and gender, these distributions are not consistent with what we would expect if JVP authors were a random sample of people, of scientists, of Earth scientists, or of paleontologists. These analyses come with several caveats, including that we consider only two categories of gender and five categories of race, and we acknowledge that much of the population may not fit into single categorizations. Our results, however, provide important insight into the state of gender and racial representation in the field of paleontology, which we hope will inform future policy and spur action to foster equitable opportunities and remove systematic barriers in the field of paleontology.

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Technical Session 11: Archosaurs (Friday, October 20, 2023, 8:00 AM)

**ASSESSING THE PTEROMORTEM POSE IN BIRDS, BATS, AND PTEROSAURS**

Perea, Isabella, Wolff, Ewan, Moore, Jason R.

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Previous research has shown that the majority of articulated pterosaurs are preserved in the characteristic “pteromortem” posture. However, the factors leading to preservation in this posture have not been fully investigated. Here we aim to study this pattern further by examining the death poses of a dataset including as much of the diversity of flying vertebrates as possible. The fragile nature of bird, bat, and pterosaur skeletons means that these taxa are frequently found as isolated, disarticulated fragments. Despite this, in certain preservational settings beautifully articulated examples of these organisms have been known for over 200 years, enabling us to quantitatively describe their death postures.

We have supplemented our previous database of 70 articulated pterosaurs with 13 further pterosaurs (collected to fill phylogenetic and body size gaps in our original sample), >40 articulated bird skeletons, and 7 articulated bat skeletons. All the specimens had their death posture described qualitatively using a consistent protocol and had their postures quantitatively assessed in ImageJ. Specimens whose postures could be interpreted as the product of postmortem taphonomic factors were excluded from analysis. As with the pterosaurs, both bats and birds showed a strong preference for preservation in a pteromortem posture. The death posture of bats was more similar to that of pterosaurs, however, demonstrating that the presence of a wing membrane was somewhat important in determining death posture, but not critical to the production of the pteromortem pose.

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**EXPLORATION OF FREE WEB-BASED MACHINE LEARNING PLATFORMS FOR PALEONTOLOGY APPLICATIONS**

Perez, Victor[1], Groff, Stephen[2], Hintermeister, Mason[3], MacFadden, Bruce J.[4]

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Artificial Intelligence (AI) technology is rapidly evolving and becoming increasingly accessible. The emergence and advancement of open-source AI tools, such as Google’s Teachable Machine (GTM) and Roboflow, provides novel opportunities for research and education that have not yet been explored for paleontological applications. Both GTM and Roboflow offer a free web-based platform to generate computer vision models using a branch of AI known as machine learning. In this study, we generated a variety of machine learning models capable of classifying 2D images of fossil shark teeth to explore the pros and cons of these two platforms, as well as identify strategies for optimizing paleontological datasets.

The images used to train these models were taken at the Calvert Marine Museum, representing six common chondrichthyan taxa that occur within the Neogene: *Carcharhinus* sp., *Galeocerdo aduncus, Hemipristis serra*, *Carcharias* sp., *Otodus megalodon*, and *Notorynchus primigenius*. Separate models were created for labial and lingual views of the teeth with 50 images per class, as well as a combined dataset, to assess the impact of specimen perspective on the models’ overall accuracy. All models performed well based on internal validation metrics, achieving 100% accuracy for each class.

However, there is a risk of overfitting within the datasets that needs to be accounted for before the models could be released for real-world applications.

Ultimately, both tools will be useful for paleontological research to keep pace with advancements in AI technology. GTM is very user friendly and ideal for basic education and exploration, but is limited in its potential for broad, real-world applications. For 2D images, the GTM platform only allows for the creation of single-label classification models and does not offer any embedded data augmentation tools. Roboflow has a more complex workflow and offers more advanced tools for collaboration, data annotation, and data augmentation that provide greater potential for research. Within the Roboflow platform, the user can create single-label classification models or object detection models, which offers more versatility for real-world applications. Additionally, Roboflow is a social media platform, in which users can make their models' freely available for public use. While GTM is easier to learn, Roboflow offers a more sophisticated tool for paleontologists to develop and share models to advance paleontological research.

**Funding Sources** This project was funded by the U.S. National Science Foundation Innovative Technology Experiences for Students and Teachers (NSF ITEST) project 2147625.

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

### MORPHOLOGICAL ADAPTATION OF THE DENTITION IN THE ORDER CARNIVORA INVOLVES GREATER TRANSFORMATIONS IN THE UPPER DENTITION THAN IN THE LOWER DENTITION

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Starting from a given morphology, adaptation to different lifestyles and environments involves the modification of structures through natural selection. The dentition of carnivores is a clear example of this. To quantify the degree of divergence in the dentition of current carnivore families, the dentition has been divided into different regions (canines, premolars, carnassials and molars) and standardized for size by dividing by the total area of the dentition. Morphological divergence quantified as the distance from the centroid of the entire order or from that of each family is generally greater for the upper dentition than for the lower dentition. This suggests differential selection pressures on the upper and lower dentition to adapt members of the order Carnivora to the different niches they occupy. This, which seems obvious for the machairodontine felids, is also observed in all other living families of both feliforms and caniforms.

**Funding Sources** Research Group RNM 146 (Junta de Andalucía). II Plan Propio Universidad de Málaga. Project PID2019-111185GB-I00 (Ministerio Ciencia e Innovación, España)

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Virtual Posters

### FEEDINGS HABITS OF PLEISTOCENE MAMMALS FROM RANCHO CARAMBANCHEL, SAN LUIS POTOSI, MÉXICO: BIOGEOCHEMICAL APPROACH

Pérez Crespo, Víctor A.[1], Pérez-Roldan, Gilberto[2], Cienfuegos-Alvarado, Edith[3], Otero, Francisco J[3]

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Rancho Carabanchel, San Luis Potosí, Mexico, is a locality where remains of late Pleistocene mammals have been found, such as bison (*Bison antiquus*), horses (*Equus cedralensis*, *E. conversidens* and *E. mexicanus*), camels (*Camelops hesternus*), llamas (*Hemiauchenia macrocephala*), javelins (*Platygonus compressus*), mammoths (*Mammuthus columbi*) and deer (*Odocoileus* sp.) as well as possible evidence of human activity. In order to understand the feeding habits and habitat of these species, carbon and oxygen stable isotope analyses were performed on dental enamel. Likewise, FT-IR-AR analyses were performed to assess the degree of diagenesis of the samples. The results obtained for the FT-IR-AR analyses show that the samples did not undergo diagenesis and the carbon and oxygen isotopic values are reliable. In the case of the carbon and oxygen isotopic ratios of the tooth enamel of herbivores, these indicate that some horses, camels and deer ate mainly $C_3$ plants and lived in forested areas while bison, mammoths, javelins and some camels and horses were fed from $C_3/C_4$ mixers. These indicate that in Rancho Caranbanchel the environmental conditions were more humid than at present and favored the presence of forest with nearby grasslands.

**Funding Sources** To PAPIIT for financial support (grants IA104017, IN101321) and M. C. Alan Ulises Laredo Jasso to support with FT-IR-ATR analyses.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**THE METABOLIC RATE OF *EINIOSAURUS PROCURVICORNIS* DETERMINED WITH PHYLOGENETIC EIGENVECTOR MAPS**

Perkins, Brynden, Reizner, Julie

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Analyses of quantitative histological traits using phylogenetic eigenvector maps have been used to determine an estimate of resting metabolic rate for several fossil vertebrate groups, including synapsids, plesiosaurs, pseudosuchians, non-avian theropods, birds, and some ornithischian dinosaurs. Ceratopsians, however, have yet to be included in any such analysis, despite their large size and importance as a diverse clade of terrestrial megafauna. *Einiosaurus procurvicornis* from the Upper Cretaceous Two Medicine Formation has extensive postcranial material available from a cohesive herd (MNI = 16). As a result, *Einiosaurus* represents one of the few ceratopsians to have extensive analysis of its bone histology, including the reconstruction of a growth curve suggesting a relatively fast rate of growth. Phylogenetic eigenvector maps can be used to provide an estimate of a given trait provided a predictor variable utilizing a phylogenetic context. In this case, relative primary osteon area represents a reliable estimator of resting metabolic rate and can be sampled from the known postcrania of *Einiosaurus*. The results can be easily compared to known values of extant taxa or to extinct taxa that have previously been sampled and analyzed. Our results represent the first quantified resting metabolic rate for a ceratopsian dinosaur, an important step toward contextualizing their physiology and evolution.

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**A REANALYSIS OF THE ARCTIC TYRANNOSAURID *NANUQSAURUS HOGLUNDI* FROM THE UPPER CRETACEOUS PRINCE CREEK FORMATION, NORTHERN ALASKA**

Perry, Zackary R.[1], Druckenmiller, Patrick S.[2], Erickson, Gregory M.[3]

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The Upper Cretaceous Prince Creek Formation (PCF) of northern Alaska is renowned for preserving the highest latitude dinosaurian fauna, consisting of at least 14 non-avian taxa. Among these includes the tyrannosaurid theropod *Nanuqsaurus hoglundi*, a purported diminutive species whose small size may reflect adaptation for survival in a limited resource environment and/or convergence towards an optimal arctic predator size. The taxonomic validity of *N. hoglundi* has been brought into question because the holotype material consists of just three fragmentary cranial bones. Furthermore, the developmental status of those remains is uncertain. Ongoing fieldwork in the PCF has resulted in the discovery of new cranial and postcranial material attributable to *N. hoglundi* providing an opportunity to reveal aspects of its anatomy, growth dynamics, and paleobiology. Here, we describe these new materials from *N. hoglundi*, reassess its taxonomic status and deduce the likely size at somatic maturity.

Based on the holotype material, the taxon is erected on problematic features, and the indicators of ontogenetic maturity are equivocal. Nevertheless, we recognize possible new diagnostic features in the currently undescribed specimens. Consistent with other work, parsimony analysis recovers the Alaskan material within Tyrannosaurinae. Histological analyses on two specimens show that both died late in development, and each lacks an external fundamental system, indicating slowing, but not cessation of somatic growth. Direct proportional scaling of all material indicates an adult skull length of 860–900 mm and a total body length of 9–10 m—considerably larger than the initially suggested skull length of 600–700 mm and body length of 4.5–5 m.

Theropod regression equations predict an adult body size of approximately 8 m and a body mass of 1620–1900 kg. Thus, the Alaskan tyrannosaurine is comparable in adult body size to other Late Cretaceous North American tyrannosaurids, such as *Albertosaurus*, *Gorgosaurus*, and *Daspletosaurus*. These findings call into question previous paleobiological assertions, and collectively provide new insights into the ecology and life history strategies of the northernmost large-bodied theropod known.

**Funding Sources** National Science Foundation EAR 1226730 and EAR 1736515

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Technical Session 21: Squamates (Saturday, October 21, 2023, 1:45 PM)

**LIFE-HISTORY PARAMETERS OF THE LATE CRETACEOUS SNAKE FAUNA OF MADAGASCAR**

Petermann, Holger, Krause, David W.

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The Late Cretaceous ophidian fauna of Madagascar is remarkably diverse, consisting of currently five recognized species representing two early-diverging alethinophidian clades. The generally larger-bodied madtsoiids *Madtsoia madagascariensis* (up to almost 8 m total length, arguably the largest snake known from the Mesozoic), *Menarana nosymena* (~2.5 m), and *Adinophis fisaka* (~1.25 m) and the overall smaller-bodied nigerophiids *Kelyophis hechti* (~1 m) and *Indophis fanambinana* (0.5–1 m) are the result of over 20 million years of evolution in isolation after Madagascar split from the Seychelles and the Indian subcontinent ca. 90 million years ago. The relatively large number of individual snake vertebrae from these five taxa allows for a detailed life-history analysis using zygantral cyclical growth marks. Such analysis is meaningful for several reasons: 1) to elucidate life-history parameters in early alethinophidians and compare them to modern taxa; 2) to study intra- and interspecific growth variability among the Late Cretaceous Madagascan ophidians; and 3) to investigate influences of environmental conditions on snake life histories.

We found that life histories of Late Cretaceous ophidians from Madagascar are remarkably similar to those of modern snakes of similar size, which indicate that life-history parameters are conservative among alethinophidians. Our largest sampled individual of *Madtsoia madagascariensis*, at ca. 5 m total length, had reached 28 years and many of the larger (~3–4 m total length) individuals were 20–25 years of age. Medium-sized (2–3 m total length) individuals of *M. madagascariensis* and *Menarana nosymena* were in their late teens, and the smaller *Adinophis fisaka*, *Kelyophis hechti*, and *Indophis fanambinana* were typically under 10 years old, although an exceptionally old individual of *A. fisaka* may have been 12 years of age. We found less intraspecific variability in the sampled ophidians than has been reported for non-ophidian squamates. Interestingly, our study did not find double and triple LAGs or exceptionally thick cyclical growth-marks that could indicate influence of environmental conditions on growth patterns. This finding suggests that snakes evolved in tandem with the semi-arid, highly seasonal environmental conditions of Late Cretaceous Madagascar.

**Funding Sources** National Science Foundation, National Geographic Society, and the Denver Museum of Nature & Science

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Colbert Poster Prize Session

**“SAILBACKS” THROUGH DEEP TIME: A COMPARATIVE OSTEOHISTOLOGICAL ANALYSIS OF HYPERELONGATE NEURAL SPINES IN *ARIZONASAURUS BABBITTI* AND OTHER AMNIOTES**

Pinto, James L.[1], Huttenlocker, Adam[2], Nesbitt, Sterling J.[3], Fabbri, Matteo[4], Ibrahim, Nizar[5], Marshall, Charles[1]

[1]Integrative Biology and Museum of Paleontology, University of California, Berkeley, Simi Valley, California, United States, [2]Integrative and Anatomical Sciences, University of Southern California, Los Angeles, California, United States, [3]Geosciences, Virginia Tech, Blacksburg, Virginia, United States, [4]Field Museum of Natural History, Chicago, Illinois, United States, [5]School of the Environment, Geography & Geosciences, University of Portsmouth, Portsmouth, United Kingdom

In the amniote fossil record, hyperelongate neural spines (HENSs), which often form a “sailback” along the axial column, have arisen independently at least 12 times, widely scattered phylogenetically and temporally. Suggestions for the functions of HENSs include that they served as thermoregulators, as display organs, and/or as biomechanical support. Osteohistology may be informative for comparing these hypotheses for HENS function, but while histological analyses of HENSs have been published for stem-mammals and dinosaurs, this work has not been done for ctenosauriscids, a group of Early-Middle Triassic pseudosuchians which evolved HENSs, or for extant taxa with HENSs, like squamates and ungulates.

Here, the osteohistology of neural spines in the ctenosauriscid *Arizonasaurus babbitti* and extant taxa *Bison bison* and *Basiliscus basiliscus* are compared with other taxa with previously described HENSs, including *Dimetrodon gigahomogenes* and *Spinosaurus aegyptiacus*. Analysis of their internal features is used to correlate with possible functions, with extant taxa that use HENSs for display (e.g., *B. basilicus*) or biomechanical support (e.g., *B. bison*) serving as a framework for the relationship between internal structure and function. Under this framework, a higher trabecular:cortical bone ratio correlates with more tissue development, concentrations of Sharpey's fibers with points of tendon attachment, and position of lines of arrested growth (LAGs) with change in rate of growth through ontogeny.

*A. babbitti* shows a higher trabecular:cortical bone ratio than any of the living taxa, and is not found to have a significant change in amount of LAGs over the shaft of the neural spine, indicating relatively constant growth through ontogeny. Sharpey's fibers were not found in its distal spine sections, or concentrated in bundles as in *B. basiliscus*. Cortical vascular canals also were observed in *A. babbitti*, with pathways to the external bone surface indicating blood flow through the neural spines. These results suggest that *A. babbitti* likely had more tissue on its HENSs than modern squamates. However, our results also show that extinct taxa have extremes in these metrics of internal bone structure or combinations of features that fall outside of the envelope of extant ones, suggesting both that convergent evolution of HENSs in these species may not represent functional convergence, and that HENSs in extinct taxa may serve functions beyond those seen in living taxa.

**Funding Sources** UC Berkeley Summer Undergraduate Research Fund (SURF) - $5,000

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Technical Session 8: Mammal Paleoecology (Thursday, October 19, 2023, 1:45 PM)

**NICHE PARTITIONING AMONG THE HERBIVORES OF NORTH-CENTRAL FLORIDA IN THE LATE MIOCENE-EARLY PLIOCENE**

Pirlo, Jeanette

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The Montbrook Fossil Site (MFS) is one of the most fossiliferous localities in the southeastern United States. This Late Miocene to Early Pliocene (late Hemphillian) freshwater site contains a unique population of terrestrial taxa, consisting of more than 2,800 cataloged elements in the Florida Museum's Vertebrate Paleontology collections. Two families of proboscideans are present, Gomphotheriidae and Mammutidae, representing over two dozen individuals of all ages. Stable carbon and oxygen isotope analyses (SIA) were employed to reconstruct the paleoecosystem, separating the populations of proboscideans into browsers and mixed feeders. This study examined the ontogenetic dietary habits of the MFS proboscideans, sampling young-of-the-year juveniles up to fully mature individuals. By expanding the SIA to the other herbivores of the site, the question of how the habitat was partitioned among the large (<46kg) to megaherbivores (>1,000kg) at the MFS was examined. Plant food resources were partitioned among primarily $C_3$ browsers (tooth enamel carbonate $d^{13}C < -10‰$), $C_4$ grazers ($d^{13}C > -1‰$), and mixed or specialized CAM feeders ($-10‰ < d^{13}C < -1‰$). Interactions between different aged proboscideans and other herbivores of similar body mass indicate potential interspecific competition between taxa at the MFS. Microwear analysis was applied to herbivores of equivalent estimated body mass, including the Rhinocerotidae, *Teleoceras*, that demonstrated similar feeding ecologies and compared, bolstering SIA results. A final unexpected result indicates a relatively stable environment over a 5-million-year period based on oxygen values ($< 2‰$ variation in $d^{18}O$) from various Florida sites during the Late Miocene, likely reflecting a sub-tropical climate, and the spread of $C_4$ grasses intensification in the Late Miocene. The MFS is a complex, rich, and biodiverse site, offering new insights into transitional terrestrial ecosystems during the Neogene in Florida.

**Funding Sources** NSF DGE 1842473, Dickinson Fellowship, Gary S. Morgan Student Research Award, Felburn Foundation, Florida Paleontological Society, & Southwest Florida Fossil Club

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Colbert Poster Prize Session

**NEOTAPHONOMIC ANALYSIS OF GALLOANSERAE EGGS: A MODERN ANALOG FOR THE PRESERVATION OF DINOSAUR EGGS**

Pittinger, Dakota R.[1], Lott, Hayley A.[1], Simpson, Edward L.[1], Zinati, Gladis[2], Aruscavage, Daniel[3], Rogers, Garrett[1], Cook, Jamie[1], Reyes, Derek[1], Scherer, Joshua[1]

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In this modern taphonomic study, the subterranean degradation and microbiome of domestic fowl (Superorder Galloanserae) eggs are analyzed over the course of four months. The purpose is to document the degradation of eggs after burial, identify biogenic and geogenic influences driving the destruction and deformation in eggs, and ultimately, emulate possible components of egg taphonomy. A total of 16 fowl eggs were selected for this study—eight from the domestic chicken (*Gallus gallus domesticus*) and eight from the domestic duck (*Anas platyrhynchos domesticus*). A box was filled with two types of substrates: on the left half of the box Type A – consisting of organic-rich topsoil from the Vegetable Systems Trial of Rodale Institute, and the right half Type B – consisting of commercial potting soil. The eggs were buried in a 4x4 arrangement with a line of four chicken eggs and a line of four duck eggs in each substrate type. Once every month, a row was excavated, photographed, and egg matter and soil proximal to the burial void were sampled. The soil samples were chemically analyzed at Rodale Institute and Kutztown University. The shell and membrane samples were processed using an Autosamdri®-815, Series A critical point dryer to remove all volatiles without altering the original cellular structure of the organic material prior to FESEM analysis. FESEM analysis over the course of four months revealed an increase in microbially-induced corrosion of eggshell cuticle and membrane. A diverse microbiome consisting of *Bacillus cereus.*, *Streptobacillus sp.*, and coccus bacteria was present on the surfaces of all of the specimens. In later specimens, bacteria were found to be embedded within the individual collagen fibers comprising the woven framework of the eggshell membrane. Additionally, fungi, plant debris, putative fowl mites, and nematodes were found in association with the buried eggs. Chemical testing of the Type A soil at the two-month mark revealed a substrate dominated by Actinomycetes and Rhizobia, followed by fungi—with protozoa comprising a small percentage of the biomass. Within 3 months, the thinner shelled chicken eggs experienced vertical compression due to the drainage of amniotic fluid into the surrounding substrate coupled with consumption by decomposers. The degradational deformation observed in this experiment provides a useful frame of reference for the study of fossil egg nest deposits and their preservation.

**Funding Sources** Kutztown University Undergraduate Research Committee

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Symposium Session: Theropod Flight Origins (Thursday, October 19, 2023, 1:45 PM)

**THEROPOD TRACKWAY FROM THE CRETACEOUS OF SOUTH KOREA PROVIDES EVIDENCE OF AERIAL BEHAVIOR IN NON-AVIALAN PARAVIANS**

Pittman, Michael[1], Dececchi, Thomas A.[2], Kim, Kyung Soo[3], Lockley, Martin G.[4], Larsson, Hans C.[5], Holtz Jr., Thomas H.[6], Farlow, James O.[7]

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Spectacular body fossils of small, feathered, paravian theropods preserving detailed soft tissue anatomy have reinvigorated the study of avian and flight origins. These body fossils set limits on feasible reconstructions of functional capacity, but do not record what these theropods did in their daily life. Existing reconstructions of function and behavior illustrate that we can only propose hypotheses of specific behavioral characteristics, regardless of how well informed and grounded we are in empirical data. Fortunately, there is already a source of data that preserves actual behaviors undertaken by fossil theropods during their lifetimes: traces such as footprints, feeding marks, burrows, and swim traces. Incorporating trace fossil data enables us to test, verify and enhance existing behavioral reconstructions of theropods. Here we reexamine a two-toed theropod trackway from the Cretaceous of South Korea, independently verifying that it was produced by a microraptorine dromaeosaurid with a hip height of ~47.5 mm and an unusually high travel speed of ~10.5 m/s. Close to the origins of birds, microraptorines include proposed aerial species like *Microraptor*. They have distinctive tracks due to a modified raptorial digit II that did not habitually touch the ground. These specific tracks assigned to *Dromaeosauriformipes rarus* are amongst the smallest of any non-avialan theropod. We estimated its mass between 10 - 15 g, making the trackmaker one of the smallest known non-avialan theropod individuals. Using this information, we explored the behavioral implications of this unusual theropod trackway. We find that this theropod trackway is not a typical cursorial-generated trackway as it evidences aerial behavior with simultaneous and reciprocating limb motions. Thus, this trackway is the first to document aerial behavior in a non-avialan theropod, supporting a broader distribution of this behavior among theropods. This study demonstrates that trackways are an important line of evidence for understanding the origins of aerial behavior in theropods, suggesting that they should be studied in greater detail moving forward.

**Funding Sources** Research Grant Council General Research Fund (17103315, 17120920, 17105221); School of Life Sciences of The Chinese University of Hong Kong (CUHK); Croucher Foundation

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Technical Session 17: Afrotheria & Mammal Macroevolution (Saturday, October 21, 2023, 8:00 AM)

**TAPHONOMY OF LATEST CRETACEOUS-EARLIEST PALEOCENE FOSSIL LOCALITIES FROM THE DENVER FORMATION OF COLORADO REVEALS THE IMPORTANCE OF MOUNTAIN PROXIMITY IN THE FORMATION, PRODUCTIVITY, AND TAXONOMIC MAKEUP OF VERTEBRATE MICROFOSSIL BONEBEDS**

Pizzini, Grace S.[1], Weaver, Lucas N.[2], Badgley, Catherine[2], Downey, Jake[2], Rogers, Raymond[3], Chester, Stephen G.[4], Lyson, Tyler[5]

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Fragmentary yet taxonomically diverse vertebrate microfossil bonebeds (VMBs) can provide important insights into ancient terrestrial and freshwater ecosystems. Our understanding of the taphonomy of VMBs comes mostly from deposits in coastal lowland paleoenvironments; however, because fluvial systems vary along elevational gradients, the mechanisms forming VMBs may differ in more mountain-proximal settings. To examine the taphonomic implications of mountain proximity on VMB formation and constituency, we examined size, shape, and taxonomic composition of VMBs from the Denver Formation (ca. 67–65 Ma) from two different areas in the Denver Basin, Colorado: Corral Bluffs and West Bijou. We then compared our data to those from VMBs from the Judith River Formation (ca. 78–75 Ma), Montana. These three settings represent a continuum of mountain proximity: Corral Bluffs is most proximal, Judith River is most distal, and West Bijou is intermediate. Vertebrate microfossils from Corral Bluffs were (1) statistically significantly larger, (2) more fragmentary and sparser, and (3) more taxonomically depauperate than those from West Bijou and Judith River, driven mostly by the low relative abundance of aquatic taxa. West Bijou and Judith River VMBs were similar in fossil abundance, shape distribution, and taxonomic constituency, but vertebrate microfossils from West Bijou were slightly larger on average than those from the Judith River. Taken together, we propose the taphonomic differences between Corral Bluffs, West Bijou, and Judith River VMBs reflect changes in both fluvial systems and the makeup of freshwater ecosystems in proximal-to-distal montane gradients. Fossil-accumulating sinks in mountain-proximal areas were likely less stable, allowing less time for vertebrate remains to accumulate, potentially capturing less of the vertebrate paleocommunity than

mountain-distal areas. Nonetheless, the presence of cimolestid and peradectid mammal teeth at Corral Bluffs indicates that hydraulic sorting did not exclude the preservation of very small fossils; instead, the larger on-average size of vertebrate microfossils and paucity of aquatic vertebrates at Corral Bluffs may reflect actual differences in vertebrate community composition in mountain-proximal regions. In sum, mountain-proximal VMBs are apparently less fossiliferous and yield primarily terrestrial and semi-aquatic vertebrate remains whereas mountain-distal VMBs are richer and dominated by aquatic taxa.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**GONIOPHOLIDID DIVERSITY IN CRETACEOUS NORTH AMERICA: INSIGHTS FROM NEW SPECIES**

Platt, Nathan C.[1], Brink, Alyson A.[2], Brochu, Christopher A.[1]

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Goniopholididae includes some of the most common and distinctive crocodyliforms from continental freshwater and estuarine deposits of Jurassic and Cretaceous Laurasia. This clade was among the first crocodyliforms with a body plan and, presumably, ecological role superficially resembling those of modern crocodylians. The flat, triangular skull and conical teeth typical of goniopholidids resemble those of most extant crocodylians and are thought to typify the configuration of a “generalized” semiaquatic ambush predator with a broad prey base. Although European goniopholidid systematics have drawn substantial attention in the past two decades, considerably less effort has been directed toward the North American record of the group.

There are seven named goniopholidids from the Jurassic of North America, while the Cretaceous record is comparatively depauperate. Only *Denazinosuchus kirtlandicus* from the Campanian Kirtland Formation of New Mexico and the poorly known *Dakotasuchus kingi* from the Cenomanian Dakota Formation of Kansas have been named, but goniopholidid material has been reported from at least seven Cretaceous formations across North America, suggesting that goniopholidid diversity in this period remains poorly understood. Here we report a crocodyliform specimen described in the literature as the "Aguja specimen" from the Campanian Aguja Formation of West Texas, based on disarticulated cranial, mandibular, and postcranial elements. A maximum parsimony analysis conducted in TNT recovers a monophyletic Goniopholididae with the Cretaceous North American goniopholidids more closely related to European forms than to Jurassic North American goniopholidids such as *Amphicotylus*. The new crocodyliform is recovered as sister to *Paluxysuchus newmani* + *Deltasuchus motherali,* with all falling out as derived goniopholidids. This novel tree topology expands the number of North American Cretaceous goniopholidids to six, highlighting previously unreported spatiotemporal diversity of this group. This also underlines the need to express caution when attributing isolated material with limited diagnostic features to the species level.

**Funding Sources** Department of Earth and Environmental Sciences, University of Iowa Paleontological Society Rodney M. Feldmann Award

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Education & Outreach Poster Session (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**INCREASING ACCESSIBILITY TO PALEONTOLOGY-RELATED EXHIBITS AT THE SMITHSONIAN'S NATIONAL MUSEUM OF NATURAL HISTORY**

Pobiner, Briana[1], Olsson, Juliana[2], Rivers, Meg[2], Behrensmeyer, Anna K.[3], Delia, Giovana[4], Dean, Kerri[2], Potts, Richard[1], Clark, Jennifer[1]

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Here we present the planning, developing, testing, and execution of three accessibility offerings in paleontology-related exhibits at the Smithsonian’s National Museum of Natural History (NMNH). Paleontological specimens and terms are often unfamiliar to visitors, creating unique challenges and highlighting the need to customize accessibility offerings. These projects targeted different user groups in different exhibit settings, but all focused on expanding access to our exhibit content.

Front-end conversations and formative testing of the Fossil Hall's Deep Time Audio Description app with blind and low-vision visitors took place in 2017-2019. Technological and spatial constraints led us to create a menu-driven mobile app using text-to-speech settings on a user's mobile device, launched in November 2019, which in turn led to an in-house visual description style. The combination of description and interpretation received positive feedback during testing (3 in-person rounds, n=8) and is now used to develop self-guided descriptions of other exhibits.

Live captioning for deaf and hard-of-hearing visitors at interactive cart activities is in development in the Hall of Human Origins using the AVA transcription app. Captions can be viewed on a visitor's personal device or a shared tablet. No internet connection, app download, or account is needed for visitor participation. Beginning in November 2022, we trained the app to recognize specialized vocabulary (e.g., taxonomic names) which increased the captions accuracy. Volunteer and visitor feedback demonstrates that the app is also useful for audiences without a hearing disability by providing context for visitors that do not have English as a first language. Language barriers are not considered a disability, but they do affect how people encounter paleontological content.

The NMNH's most recent DiY ("Do it Yourself") exhibit is the Human Origins DiY exhibit, which condenses the permanent Hall of Human Origins exhibition content into 20 free print-on-demand poster files. This exhibit was translated into 11 languages by May 2023: Spanish, French, Arabic, simplified Chinese, traditional Chinese, Portuguese, Vietnamese, Hindi, Indonesian, Japanese, and Amharic. The DiY exhibit low-cost nature and flexible language format increases potential access to the exhibit content by >3.5 billion additional people. We anticipate that lessons learned from these projects will be applied to future accessibility efforts across NMNH.

**Funding Sources** David H. Koch, The Congress of the United States, The Peter Buck Family, and The William J. Graham Fund

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Technical Session 1: Sauropod & Ornithischian Dinosaurs (Wednesday, October 18, 2023, 8:00 AM)

**NEW DINOSAUR DISCOVERIES IN THE LA COLONIA FORMATION: INSIGHTS INTO THE LATE CRETACEOUS FAUNA OF PATAGONIA BEFORE THE K-PG EXTINCTION EVENT**

Pol, Diego[1], Becerra, Marcos[2], Carballido, Jose L.[1], Krause, Marcelo[1], Baiano, Mattia[3], Pittman, Michael[3]

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The La Colonia Formation contains the most important record of latest Cretaceous vertebrates from Central Patagonia and recent geochronological work has constrained this unit to be deposited between 69 and 64 Ma. So far, it is the only unit in South America that preserves an abundant terrestrial fauna and is dated precisely to record the biodiversity dynamics before the K-Pg mass extinction event. Collecting efforts over the last two decades yielded a diverse vertebrate fauna including dipnoans, anurans, mammals, ophidians, turtles, dinosaurs, and plesiosaurs. Recent exploration that yielded four new dinosaur species for this unit. First, a new abelisaurid theropod represented by an articulated partial skeleton with cranial remains reveals a second member of this clade for the unit, in addition to *Carnotaurus*. Skull features indicate this taxon lacked horns, bear nasal ridges and associated foramina, and had a small parietal crest, suggesting an array of cranial plesiomorphies. Second, a virtually complete postcranial skeleton of an ankylosaurid with an associated skull roof and lower jaw indicates the presence of a small bodied and slender limbed new taxon. Postcranial features reveal the presence of synapomorphies of the recently recognized Gondwanan clade Parankylosauria, including a caudal shield of osteoderms. The skull, sacrum, and pelvis reveal numerous differences with *Stegouros*, indicating large morphological disparity within this poorly known clade. Third, an articulated skeleton of a hadrosaur with a complete skull represents the most complete hadrosaur from South America. It shares with other South American kritosaurini the presence of cranial synapomorphic features but represents a new taxon due to numerous cranial features (e.g., absence of a V-shaped nasofrontal suture; dorsoventrally high maxilla with short palatal process; narial fossa restricted to the posterodorsal portion of the premaxilla; lack of a prominent nasal crest). Fourth, a dissarticulated titanosaurian specimen with vertebral, pelvic, and appendicular elements represent a new small titanosaurian taxon. The humerus and femur with robusticity indices, femur with dorsomedially directed head, and strongly compressed shaft suggest affinities with Saltasaurinae. These new taxa, coupled with vertebrates and the recently established age of the formation, demonstrate the persistence until the end of the Cretaceous of a distinct fauna recorded since the Campanian of Patagonia.

**Funding Sources** National Geographic Society NGS-92822R-22, FONCYT PICT 2018-00605

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Romer Prize Session (Thursday, October 19, 2023, 8:00 AM)

**JAW MECHANICS IN SHREWS AND THE ROLE OF THE DOUBLE ARTICULATION**

Pommerening, Sebastian

Rheinische Friedrich-Wilhelms-Universität Bonn, Bonn, Germany

Essential for sustaining a high metabolic rate is the efficient fragmentation of food, which is determined by the molar morphology and the movement of the jaw. The latter is related to the jaw morphology and the arrangement of the masticatory muscles. Already in early Mammaliaformes such as *Morganucodon oehleri* the typical mammalian arrangement of the three masticatory muscles (temporalis, masseter, pterygoid) and their subdivision into two parts were present. The evolution of the angular process which enlarged the insertion areas for the internal pterygoid muscle and the masseter is either linked to an increasing yaw (rotation around the vertical axis) or to an enhanced roll movement (rotation around the longitudinal axis) during the chewing stroke.

Besides the development of a remarkably elongated angular process, the mandible of shrews is unique by its condylar process that has the articulation facet separated into a dorsal and a ventral part. This double articulation is thought to allow a more differentiated movement of the jaw. By study of tooth wear, virtual reconstructions of the chewing paths by the Occlusal Fingerprint Analyzer software, and the application of diceCT, a non-destructive technique for visualizing soft tissue, we show that the double articulation allows a combination of yaw and roll rotation. These complex movements are governed by the two muscles inserting on the angular process. In conjunction with the contraction of the temporalis muscle, mainly responsible for the pitch motion (rotation around the transverse axis), the lower jaw gets rolled into occlusion (Phase I). The grinding of the protocone through the talonid basin in Phase 2 is accompanied by an alternation of inversion and eversion of the mandible, which occurs either within one chewing stroke or during subsequent strokes. Responsible for the inward rolling is the masseter muscle while the eversion is induced by the contraction of the internal pterygoid muscle.
These rotational movements allow for an enhanced fragmentation of food by induction of a twist motion to the bolus in Phase I and a more varied grinding by additional moving directions of the protocone in Phase II. This permits a more efficient energy gain and the maintenance of a high metabolic rate which is crucial for small-bodied mammals such as shrews.

**Funding Sources** Deutsche Forschungsgemeinschaft (DFG)

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Technical Session 12: Methods & Paleohistology (Friday, October 20, 2023, 8:00 AM)

**THE LION, THE GOAT, THE SNAKE AND A HERO: DEFEATING CHIMERAS USING THE "BELLEROPHON METHOD"**

Powers, Mark J.[1], Nydam, Randall[2], Caldwell, Michael W.[1]

[1]Biological Sciences, University of Alberta Faculty of Science, Edmonton, Alberta, Canada, [2]College of Osteopathic Medicine, Midwestern University, Glendale, Arizona, United States

Bellerophon famously defeated the Chimaera, a monster comprised of lion, goat, and snake parts. Here we propose a set of rules we call, "The Bellerophon Method", for addressing the problem of chimaeras in vertebrate paleontology. Due to the fragmentary nature of fossils, many species have been erected around single elements, or more to the point of chimaeras, from associations of isolated elements to increase the data used to diagnose the taxon. This is particularly true with microvertebrate remains where species have been erected based on combinations of isolated to partial skeletal remains, often in mixed taxic assemblages, sourced in some cases from disparate localities, some of which are separated by long periods of time. Although morphological comparison is the only direct means for referring specimens to type material, chimaeras arise from loose practices of referral based on size, association, stratigraphic correlation, broader clade similarities and other indirect comparisons, which have become accepted as methods for increasing data for a species diagnosis. The recent redescription of *Coniophis precedens* illustrates this problem clearly, where the original diagnosis from a single isolated vertebra was expanded to include dozens of vertebrae and four jaw fragments from widely disparate field localities. A more recent example is the attempt to expand the diagnosis of *Diablophis gilmorei* to include additional elements from a single block also containing mammal and sphenodontian remains. Based on these and other examples, we propose a set of principles to deconstruct current chimeras and avoid creation of others (the Bellerophon Method): 1) Co-occurrence is insufficient for referral of isolated elements; microsites are usually multi-taxic and multiple species of varying types (i.e., mammal, lizard, fish, etc.) are expected; 2) Referred isolated elements require connectivity; where cranial and postcranial material are referred to the same taxon, there should be evidence of their connectivity (i.e., articulation, complementary contact surfaces, or observed connectivity in a referred specimen); 3) Diagnostic material should be chosen from the best anatomical representations and not include referred elements; holotypes, when erected from limited material, should be material with more complex and compound anatomy (i.e., jaw bones), and referrable material should only be used for description.

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Education & Outreach Poster Session (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**SPECIATE: A NOVEL METHOD FOR TEACHING PALEOGEOGRAPHY AND SPECIATION IN A BLENDED DELIVERY UNDERGRADUATE PALAEONTOLOGY COURSE**

Powers, Mark J.[1], Bradley, Gavin[2]

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Paleo 201: Dinosaurs in the Fossil Record is a blended, second year undergraduate course at the University of Alberta in which students build off the material of the Dino 101 Massive Open Online Course (MOOC) with in-class lectures, field trips, and active learning activities. Each hands-on active learning session is developed based on learning outcomes from a module in the MOOC. When paired with hands-on instruction, learning outcome-based assessments, and incentives such as participation grades, active learning can benefit student performance in undergraduate STEM classrooms and narrow achievement gaps for underrepresented students in tertiary education.

The most challenging concepts from Dino 101 are paleogeography and speciation. To address the potential gap in these outcomes, a new paleogeography board game activity was introduced in the Winter 2023 semester. Game Based Learning (GBL), has been successfully used in undergraduate STEM classes to better communicate difficult concepts, including those within paleontology.

In the game Speciate students play as a species attempting to disperse across a world of changing continents. Population tokens are placed in adjacent territories to demonstrate dispersal. Species evolve by acquiring and losing traits through mechanisms like genetic drift and undergo speciation through vicariance, competition or by adaptive radiation. Players will observe the effects of plate tectonics on terrestrial vertebrate populations and how these processes drive evolution. Extinction and adaptive radiation are simulated by major events like sea level changes, volcanism, disease, and bolide impacts drawn between rounds. During gameplay, instructors guide play and intervene when necessary, making sure that students feel supported in the activity. Learning outcomes are then tested using formative assessments that prompt students to reflect on drivers of speciation through geological time in a dynamic system of geological and biological factors.
Initial feedback was positive and included suggestions for new mechanics, demonstrating a high level of engagement. In the Fall 2023 semester, we intend to apply for teaching and learning development funding to create more durable boards and player pieces, implement student-suggested changes to game mechanics (i.e., minor event cards) and collect formalized qualitative and quantitative feedback on student engagement, as well as assessment performance on the outcomes covered in the activity.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

## NEW *BASILEMYS* TURTLE FROM THE UPPER CRETACEOUS FRONTIER FORMATION NEAR LIMA, MT

Prall, Jack, Panascí, Giulio, Hannebaum, Zakaria, Orme, Devon A., Varricchio, David J.

Montana State University, Littleton, Colorado, United States

In the Summer of 2021, a partial carapace and plastron of a turtle was recovered from the lower Frontier Formation, near the town of Lima in southwestern Montana. The specimen possesses ornate sculpturing of rows of triangular tubercules separated with pits, and can be assigned to *Basilemys*, a large, terrestrial turtle that is well known from the upper Late Cretaceous in North America. This *Basilemys* specimen comes from a thick, calcareous paleosol which lacked stratigraphic constraints. We apply detrital zircon U-Pb geochronology using laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) to constrain the depositional age of the stratigraphic interval. Results yield a maximum depositional age for the paleosol as Lower Coniacian (88.92 ± 2.4 Ma) and mark this as the earliest dated occurrence of the genus. The pre-Santonian fossil record of *Basilemys* is scarce. Fragmentary material is reported from the Straight Cliffs Formation of Utah, and it is broadly assigned to middle Coniacian-upper Santonian deposits. The Frontier fossil material therefore represents the earliest record of the genus so far. Additionally, *Basilemys* is the only member of Nanhsiungchelyidae known in North America, a clade that otherwise remained in eastern Asia. This specimen suggests that the dispersal of nanhsiungchelyid turtles into North America had already begun by Coniacian time.

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Virtual Posters

## A NEW EARLY-DIVERGING HADROSAURID (DINOSAURIA: ORNITHOPODA) FROM THE UPPER CAMPANIAN AGUJA FORMATION OF TRANS-PECOS TEXAS, USA

Prieto-Marquez, Albert[1], Wagner, Jonathan R.[2]

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Saurolophids constitute the major radiation of hadrosaurid ornithopod dinosaurs, consisting of unadorned and ‘solid-crested’ forms (Saurolophinae) and ‘hollow-crested’ Lambeosaurinae. This group is well-represented in the fossil record, especially from their diversity acmes in the middle-upper Campanian of North America and Campanian-Maastrichtian strata of Eurasia. Less is known of the diversity and evolution of the proximal outgroups to Saurolophidae. We describe a previously unrecognized genus and species of non-saurolophid hadrosaurid, *Malefica deckerti*, from the middle- to upper Campanian upper shale member of the Aguja Formation in Big Bend National Park, southwestern Texas, USA. This taxon is solely represented by a partial left maxilla. The maxilla is a structural keystone of the hadrosaurid facial skeleton; its complex articulations with many other elements renders the maxilla rich in character data, and the element often expresses morphology diagnostic to lower taxonomic levels. *M. deckerti* is diagnosable by several autapomorphies and a unique combination of character states. Autapomorphies include: deep, broad moat-like space separating anterodorsal promontory from lateral surface of dorsal process; anterodorsal promontory extending posteriorly as prominent ridge onto jugal facet; and ‘inflated,’ block-like jugal process.

The phylogenetic position of *M. deckerti* as one of the closest outgroups to Saurolophidae adds to the growing evidence that basally-branching hadrosaurids were widespread in the Northern Hemisphere. This new species improves our perspective on the evolution of facial attributes during the saurolophid radiation. Expansion and levelling of the maxillary ectopterygoid shelf may have preceded the expansion of the toothrow, dorsoventral deepening of the jugal facet and reduction of the jugal process to a tubercle. The increase in area of the ectopterygoid shelf may reflect expansion of the jaw adductor musculature to produce stronger bite forces, while reorientation of the shelf may reflect a shift in the direction of muscle action although the functional result of this change is unclear. This was followed by expansion of the occlusal plane by the addition of replacement teeth to the functional surface, to take advantage of the increased musculature for grinding. Change in the jugal facet and process may reflect modification of the maxillary-jugal joint to permit putative cranial kinesis for more aggressive mastication.

**Funding Sources** Grants RyC-2015-17388 and PID2020-119811GB-I00 funded by

MCIN/AEI/10.13039/501100011033 and CERCA Programme funded by Generalitat de Catalunya

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**A NEW VERTEBRATE-BEARING LOCALITY FROM THE CARNIAN (LATE TRIASSIC) OF VIRGINIA (NEWARK SUPERGROUP, TAYLORSVILLE BASIN)**

Pritchard, Adam C.[1], Kligman, Ben T.[2], Olsen, Paul E.[3], Stevens, Michael[1], Sues, Hans-Dieter[4], Treado, Lucy[1], Weems, Robert[5], LeTourneau, Peter[3]

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The Carnian-Norian Taylorsville Basin (TVB) includes some of the oldest Mesozoic fossils in the mid-Atlantic region of North America. Exposed at various sites northwest of Richmond, Virginia, USA, the TVB has primarily produced redfieldiiform fish, with less common coelacanths and semiontids. Tetrapod fossils include the partial skeleton and isolated bones of the doswelliid archosauriform *Doswellia kaltenbachi,* as well as isolated bones of poposauroid archosaurs and other unidentified reptiles.

Here, we report on a new vertebrate-bearing locality near the town of Ashland in Hanover County, Virginia from the Falling Creek Formation of the basal Doswell Group, the lowest unit of the TVB section. The site occurs along a tributary of South Anna River that exposes a linear kilometer of interbedded fossiliferous conglomerates, sandstones, mudstones, and microlaminated siltstones. The mapped stratigraphic position of this outcrop places it within correlative, and lithologically similar Carnian age strata identified in outcrop and in industry rock cores and cuttings from the TVB.

The siltstones produce abundant spinocaudatans (clam shrimp), skeletons of semionotiform and redfieldiiform fishes, and one conical, striated reptile tooth. A well-preserved blattodean and partial beetle elytra indicate that these siltstones may represent an insect lagerstätte. The less-well laminated mudstones are dominated by plant fossils, including bennettitalian leaves, stems and leaves of the conifer *Pagiophylum*, horsetails, and wood fragments. Animals are represented by bivalve steinkerns and by a bromalite containing ganoid fish scales.

The sandstones have produced indeterminate plant fragments and vertebrate fossils. Fish fossils include isolated, three-dimensionally preserved actinopterygian skull elements and scales. Reptile materials are dominated by unserrated conical teeth and rare serrated teeth. Archosauromorph materials include one partial limb skeleton and an association of two vertebrae and a rib. The new reptile fossils differ from equivalent elements in *D. kaltenbachi*, indicating a higher diversity of reptile taxa from the TVB than previously known. Apomophically identifiable phytosaur fossils are absent, as is true of known Carnian age strata in eastern North America. These records add to the developing picture of the Carnian-Norian transition in North America and valuable points of floral and faunal comparison for similar-age basins of the southern Newark Supergroup.

**Funding Sources** This project was financially supported by the Virginia Museum of Natural History Foundation. Fieldwork support and equipment were provided by the landowners.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**SYSTEMATICS OF THE LONG-NOSED FLORIDATRAGULINE CAMELS (ARTIODACTYLA: CAMELIDAE)**

Prothero, Donald R.[1], Beatty, Brian L.[2]

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The weird-looking tubular-snouted camels known as floridatragulines have been a controversial group ever since the first specimens were found in the 1930s. We describe only the second known skull of *Floridatragulus dolicanthereus,* which gives us a better understanding of their cranial anatomy and proof of association of the jaws and skull, because the holotype skull was badly crushed and mostly

restored in plaster. *Floridatragulus* is not an isolated genus, but part of the subfamily Floridatragulinae, which have a fossil record going back to the late Eocene. The late Eocene "*Poebrotherium" franki* from Trans-Pecos Texas is here renamed *Stevenscamelus franki* and represents the oldest known floridatraguline. No floridatraguline fossils are known from the Oligocene, possibly due to the scarcity of terrestrial fossils in the Gulf Coast Plain at that time. The earliest Miocene (latest Arikareean) *Aguascalientia* was a slightly larger, more derived taxon, known from four species from Mexico, Texas, and Panama. Finally, we recognize three valid species of the genus *Floridatragulus* from the early Miocene (early Hemingfordian-Barstovian) of Florida and Texas. Floridatragulines were an early and primitive branch of camelids, more derived than poebrotherines and miotylopines-stenomylines, but more primitive than the miolabines and protolabines. They were restricted to the warm humid subtropical to tropical coastal settings of the Gulf Coastal Plain of Texas, Florida, and Central America.

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Technical Session 9: Sauropsids (Thursday, October 19, 2023, 1:45 PM)

**CLAWS IN THE CAUDALS; UNIQUE MORPHOLOGY AMONG DREPANOSAURID (DIAPSIDA) CAUDAL ELEMENTS**

Pugh, William I., Sodano, Megan, Kligman, Ben T., Stocker, Michelle R., Nesbitt, Sterling J.

Geosciences, Virginia Tech, Blacksburg, Virginia, United States

Across the diversity of tetrapod body plans, the shape of some skeletal regions have remained remarkably conserved for hundreds of millions of years. Among these conserved elements are caudal vertebrae, especially in reptiles. However, in one reptile group, the drepanosaurids, distal caudal elements are modified into a terminal claw-like element ("tail claw") hypothesized to have a mobile, potentially prehensile joint. These "claws" are sometimes found in isolation but are also known in articulated specimens. We present the first evidence of homologies between these tail claws and caudal vertebrae and describe unique morphotypes over tens of millions of years of the Late Triassic. Diagnostic features of tail claws distinguishing them from limb unguals include a proximo-ventral concave surface, a lateral expansion on the distal margin of the concave surface, and a unique bicondylar articulation with the adjacent centrum. Lateral grooves and a series of smaller grooves are present in all well-preserved tail claws, indicating the presence of a keratin sheath analogous to that covering manual and pedal unguals. A dorsal foramen presumably homologous to the neural canal of caudal vertebrae is commonly preserved. CT data suggests a second channel innervated the ventral surface, likely associated in life with haemal arch-like ridges seen on the ventral surface of some specimens. Tail claw morphology is variable across species, with differing depth and degree of lateral expansion in the proximo-ventral concavity. However, the most notable variation is the presence or absence of a centrum-like proximal portion. This portion is almost certainly homologous to a distal caudal centrum because a similarly shaped vertebrae articulates in the same location on unfused specimens. That fused element also possesses a dorsal ridge much like a low neural spine atop a neural canal-like channel. Hence, the likely prehensile tail and tail claw of drepanosaurids is composed of multiple modified and fused elements as opposed to a single "claw." Given our observations, it is likely that tail claws are diagnostic between drepanosaurid species and that tail claw morphotypes can be used as a proxy for the number of drepanosaurid taxa present where one or no manual claw morphotypes have been recognized. These modifications represent a bizarre expansion of caudal element morphospace as well as a unique approach to developing a prehensile tail.

**Funding Sources** National Science Foundation Graduate Research Fellowship Program

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Technical Session 6: Marine Reptiles (Wednesday, October 18, 2023, 1:45 PM)

**A NEW HUPEHSUCHIAN (REPTILIA: ICHTHYOSAUROMORPHA) FROM THE LOWER TRIASSIC OF SOUTH CHINA SHOWING CONVERGENT EVOLUTION OF POLYDACTYLY**

Qiao, Yu[1], Motani, Ryosuke[2], Iijima, Masaya[3], Liu, Jun[1]

[1]School of Resources and Environmental Engineering, Hefei University of Technology, Hefei, Anhui, China, [2]Department of Earth and Planetary Sciences, University of California, Davis, Davis, California, United States, [3]Department of Comparative Biomedical Sciences, Royal Veterinary

College, North Mymms, Hertfordshire, United Kingdom

Hupehsuchia, an enigmatic group of marine reptiles from the Lower Triassic of South China, is characterized by a suite of features including paddle- or flipper-shaped limbs. Interestingly, some hupehsuchians show more than five digits in either or both fore- and hind limbs, and one specimen in particular, shows seven-digited forelimbs and a six-digited hind limb. However, questions remain as to whether these extra digits represent evolutionary acquisitions, and if so, in what sequence the manus configuration evolved in hupehsuchians. Here, we describe a new parahupehsuchine hupehsuchian with seven manual digits associated with extra carpals and metacarpals, which renders support to the evolutionary acquisition hypothesis. Our new phylogeny revealed the evolutionary sequence of polydactyly in hupehsuchians, where the extra digits were added through two different mechanisms, preaxial and central polydactyly. Polydactyly of the manus evolved stepwise in hupehsuchians, increasing the efficiency of propulsion during swimming. These extra digits in hupehsuchians seem to only increase the hand plate width and did not reduce the digit thickness, which may reflect *Shh*/Gli3 pathway-dominated gene regulation mechanism.

**Funding Sources** This research was supported by the National Natural Science Foundation of China (grant numbers 42172026) and the China Scholarship Council (grant number 202106690044).

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Romer Prize Session (Thursday, October 19, 2023, 8:00 AM)

**MORPHOLOGICAL DIVERSITY AND FUNCTIONAL ADAPTATIONS OF MANIRAPTORAN MANUAL CLAWS**

Qin, Zichuan[1], Wang, Shiying[2], Deakin, William[1], Liu, Yuming[1], Yu, Congyu[3], Xu, Xing[4], Benton, Mike[1], Rayfield, Emily[1]

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Maniraptorans ('hand snatchers') are a clade of theropod dinosaurs that includes birds and their ancestors. Despite the name of the clade, maniraptoran hand morphologies differ substantially and perform many functions. The ungual elements, the tips of the fingers, exhibit the most distinctive morphologies among all manus elements and potentially bear high stress when functioning. Previous functional studies have focused mainly on morphological parameters (e.g., curvature) or simulation studies that are specific to certain behavioral scenarios. Here we characterize the shape and determine the functional performance of maniraptoran manual claws via a novel theoretical morphospace method. We combine finite element analysis (FEA) for functional simulation and a Pareto ranking system to assess optimality of claw performance across three different loading scenarios: scratch-digging, hook-and-pull, and climbing. These approaches allow us to explore occupied and unoccupied morphospace and trade-offs between different motor functions in order to determine the biological roles of maniraptoran manual claws across the clade and during the transition to flight. Our dataset includes 40 3D manual ungual FE-models, and 274 2D manual claw shapes from 130 Mesozoic maniraptorans. Using a custom-built pipeline in MATLAB and R we estimate von Mises stress (VMS) and deformations in the claw across the three functional scenarios and calculate mechanical advantage (MA, claw leverage), and a proxy for speed of movement, rotational efficiency (RE). We create performance landscapes of theoretical and realized claw shapes and map the evolution of claw performance and functional trade-offs to maniraptoran phylogeny. We find multiple instances of high-performance climbing claws in Maniraptora, and a later appearance in arboreal crown birds. Enantiornithes and Euornithes had different claw climbing abilities, possibly evidence of ecological niche divergence, and potentially linked to limb reduction in Euornithes. The ancestral state for Maniraptora is optimal grasping performance, a state lost independently several times, in some cases by reduction of forelimbs, in others by adopting other functions. We also find optimal grasping function re-emerged in some lineages, probably related to hypercarnivory. This research provides a fresh perspective on the mosaic evolution of maniraptoran forelimbs, the promise to be extended to other highly functional biostructures such as teeth and horns.

**Funding Sources** Jurassic Foundation research funding for ZC.Q, NERC funding (NE/L002434/1.) for W.D.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

## A NEW POROLEPIFORM FISH FROM THE MIDDLE DEVONIAN, QUJING, YUNNAN, CHINA

Qu, Chenyang[1], Pan, Zhaohui[1], Zhao, Yingtian[2], Zhu, Min[1], Lu, Jing[1]

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Porolepiformes is an important dipnomorph (lungfish lineage) group that lived exclusively during the Devonian period. They were distinguished by their dendrodont teeth, the presence of the subsquamosals, a single marginal bone alongside the postparietal, and the otic part of the main lateral line passing through the center of the postparietal. So far, 14 genera of porolepiforms have been described, with most of them found in Europe and North America. Previous studies have revealed that South China is the origin center for sarcopterygians, and the earliest representative of the dipnomorph has been found in China. However, only a few porolepiform scales have been documented in the Early Devonian of China, thus the origin and early diversification of the group remains unclear. Here, we present a new form of porolepiform from the Middle Devonian of Zhujiangyuan, Qujing, Yunnan Province, China. High-resolution computed tomography reveals some unusual features in this new form, such as cosmoid cycloid scales, a cleaver-shaped maxilla, and a narrow, crescent-shaped jugal. The M-shaped premaxilla with an enlarged anterior tooth and inturned symphyseal process recalls the condition in primitive osteichthyan *Psarolepis*. The round cosmoid scales in the new form shows a transitional stage between cosmoid rhombic scales of porolepids and round scales without cosmine of holoptychiids. The new phylogenetic analysis focused on the porolepiform interrelationships shows that the new form is crownwards to Porolepididae, forming the sister group of Holoptychiidae. The new porolepiform from the Middle Devonian of South China highlights the worldwide distribution of the group and provides new evidence for understanding the character transition sequence during porolepiform evolution.

**Funding Sources** the Strategic Priority Research Program of Chinese Academy of Sciences (XDB26000000), the National Natural Science Foundation of China (42022011)

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

## FOSSIL CANIDS FROM VENEZUELA

R. Ramoni, Damian

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In Venezuela, there are three types of wild canids that are currently living: *Urocyon cinereoargenteus*, *Cerdocyon thous*, and *Speothos venaticus*. However, a review of previous paleontological material and newly discovered ancient specimens reveals a greater historical diversity in the same area. The gray fox, *U. cinereoargenteus*, is the only small-sized and the only Vulpini (true fox) species found in the fossil record of Venezuela, and it is limited to the Late Pleistocene of the Mene de Inciarte site in Zulia State. On the other hand, larger canids are more abundant. *Aenocyon dirus*, the dire wolf from the Late Pleistocene, was found in El Mene de Inciarte and Muaco in Falcón State, and for the first time in El Breal de Orocual (ORS20) in Monagas State. The native South American canid genus *Protocyon* (subtribe Cerdocyonina) has been identified in the country from Late Pleistocene Inciarte (*Protocyon troglodytes* sensu lato) and Late Pliocene–Early Pleistocene Orocual (ORS16) (*Protocyon orocualensis*). Finally, a possible genus *Theriodictis* has been reported from the Late Pleistocene Orocual, a Cerdocyonina not previously mentioned for the northern region of South America. These findings reveal a broader diversity and suggest a more complex evolutionary history for South American canids than previously thought.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

## A NODOSAUR TRACK (*TETRAPODOSAURUS*) FROM THE EARLY CRETACEOUS SYKES MOUNTAIN FORMATION OF WYOMING

Radermacher, Viktor J.[1], Makovicky, Peter[1], Suarez, Celina A.[2], Suarez, Marina[3], Allen, Matthew[3]

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Ankylosaurs were obligately quadrupedal herbivorous dinosaurs covered in thick protective osteoderms. Despite never achieving any ecological superiority, ankylosaurs still established themselves as modest medium-large bodied mainstays of Mesozoic ecosystems since their evolution in the Middle Jurassic. Nodosauridae, a particularly spiked clade of ankylosaurs, is commonly represented in the Early Cretaceous record of the Western United States by body fossils of *Sauropelta edwardsorum* in the Cloverly Formation of Wyoming and Montana. Here we report an intact three-dimensionally preserved cast of a symmetrical 400 x 400 mm track preserving four equally sized and spaced blunt digits, tapering to a subtriangular heel. A distinct mediolaterally continuous trough is present just behind the boundary defined by the digits. These observations allow us to confidently diagnose this as a right pedal cast of the ichnofossil *Tetrapodosaurus* – a trace originally made by nodosaurid ankylosaurs. This track was recovered from the western part of the Bighorn Basin in Wyoming from the bottom of the Sykes Mountain Formation (late Albian-early Cenomanian), just above its conformable contact with the underlying Cloverly Formation. Curiously, stratigraphically comparable strata from Virginia and British Columbia, Canada, lack nodosaurid body fossils but preserve nodosaurid trackways referred to the ichnotaxon *Tetrapodosaurus*. The Early Cretaceous fossil record of ankylosaurians in North America is marked by an ichnological record and a body fossil record (*Borealopelta, Sauropelta, Tatankacephalus*) that are geographically disjunct. The track we report here is the first record of a nodosaur track in the Early to mid-Cretaceous of North America that coincides both geographically and in close stratigraphic proximity with nodosaur body fossils (*Sauropelta* and *Tatankacephalus*).

**Funding Sources** National Science Foundation, NSF-FRES EAR 1925884

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**CRANIAL ONTOGENY IN THE NOTOSUCHIAN CROCODYLIFORM *MIADANASUCHUS OBLITA* FROM THE UPPER CRETACEOUS MAEVARANO FORMATION, NORTHWESTRN, MADAGASCAR**

Rakotozafy, Bakoliarisoa[1], Sertich, Joseph J.[2], O'Connor, Patrick M.[3]

[1]Denver Museum Of Nature and Science, Denver, Colorado, United States, [2]Colorado State University, Fort Collins, Colorado, United States, [3]Ohio University, Athens, Ohio, United States

The diversity of Late Cretaceous vertebrates from Madagascar is known predominantly from the Maastrichtian Maevarano Formation, a unit of fluvial- and debris-flow deposited sedimentary rocks exposed in the Mahajanga Basin. Maevarano Formation crocodyliforms are particularly diverse, with six documented taxa. *Miadanasuchus oblita*, a medium sized (e.g., 3 m estimated adult body size) terrestrial carnivore, is hypothesized to be a member of Peirosauridae. As most peirosaurids are currently established on individual specimens, many presumed to be adult, our knowledge of ontogenetic shifts in morphology are extremely limited. The recovery of numerous partial-to-complete and size-diverse skulls of *Miadanasuchus* from the Maevarano Formation provide a unique opportunity for examining cranial ontogeny at both whole skull and individual bone levels. In this study, we investigate *Miadanasuchus* ontogeny from the perspective of body size and potential changes in ecological niche throughout life. Our sample includes hatchlings, juveniles, subadults, and adults, ranging in estimated skull length between 3 cm for the hatchling and ~30 cm for the largest adult form. Notable changes in morphology over this size range include: alteration of surface texture from relatively smooth to heavily sculpted, fusion of composite bones (e.g., the nasals), and moderate shape change in selected elements (e.g., frontal, parietal, squamosal, lacrimal, and dentary). The latter two categories of shape change are possibly related to functional dietary shifts through growth. For example, the fusion of the nasals in juveniles and adults likely relates to an increased need for biomechanical stability as acquiring larger prey items would result in higher loading through the rostrum during feeding. Changes of body size, along with concomitant shape changes in the skull and dentition through development, potentially reflects a combination of prey preference and habitat. *Miadanasuchus* is the only crocodyliform currently known from the Miadana Member and is the most

common terrestrial crocodyliform from the tidal flat deposits of the Kinkony Member of the Maevarano Formation. Interestingly, its co-occurrence with other Maevarano crocodyliforms in the fluvial/debris flow-dominated Anembalemba Member suggests some level of dietary specialization in addition to habitat/spatial segregation.
**Funding Sources** NSF DBI_2242717, NSF EAR_1525915

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Technical Session 18: Synapsids (Saturday, October 21, 2023, 8:00 AM)

**3D ANATOMY OF THE CRANIOMANDIBULAR JOINT OF DERIVED SOUTH AMERICAN CYNODONTS AND HOMOPLASY IN THE EVOLUTION OF THE MAMMALIAN JAW**

Rawson, James[1], Gill, Pamela[1], Martinelli, Agustin[2], Soares, Marina[3], Schultz, Cesar[4], Rayfield, Emily[1]

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Previous research has described morphological changes to the jaw and postdentary bones across the cynodont/mammaliaform transition concerning the formation of the mammalian dentary-squamosal jaw joint. However, more recently discovered non-mammaliaform probainognathian cynodonts from South America have thus far not been wholly integrated into comparative anatomical studies, despite being represented by numerous specimens, including ontogenetic series. In this study, micro-CT data from twelve cynodont species, including nine specimens of *Brasilodon quadrangularis*, the sister taxon to mammaliaforms, and ten specimens of the tritheledontid *Riograndia guaibensis*, were segmented to produce 3D descriptions of the jaw articulations of these taxa, many for the first time. Hitherto unknown morphology visible in our scans overturns previous descriptions of jaw joint anatomy and demonstrates homoplasy in the approach to mammaliaform morphology, similar to that seen in the independent acquisition of the definitive mammalian jaw joint and middle ear in Mesozoic mammals. *Brasilodon,* contrary to previous interpretations, lacks a clear squamosal-dentary articulation and instead relies solely on a quadrate-articular joint, while *Riograndia* possesses a developed squamosal-dentary contact to reinforce the already robust primary jaw joint. We find that jaw joint evolution accelerates crownwards in cynodonts, beginning with the acquisition of a secondary jaw joint in eucynodonts and followed by a notable increase in morphological experimentation in derived probainognathians, that occurred alongside the evolution of other key mammalian features.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**NEW INSTANCES OF CERATOPSIAN (DINOSAURIA: CERATOPSIA) TEETH FROM APPALACHIA IMPLY MULTIPHASE LATE CRETACEOUS MIGRATIONS**

Rayburn, Kenneth C.[1], King, J. Logan[2], Varriale, Frank[3], Son, Minyoung[4], Phillips, George[5]

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Non-avian dinosaur remains from the Late Cretaceous of southern Appalachia are consistently rare. Typically, fossils are fragmentary though six clades are represented. Among these clades, ceratopsians are perhaps the rarest with only three potential basal neoceratopsians and one ceratopsid being recorded to date. Here, we describe two new teeth that we attribute to a ceratopsian from the Late Santonian aged Tombigbee Sand Member of the Eutaw Formation of Lowndes County, Mississippi. The maxillary teeth differ from those from more common hadrosauriforms found throughout southern Appalachia by having smaller secondary ridges that are apically located and do not reach the cingulum; being roughly equal in width and height; and having apically oriented denticles. The teeth favor ceratopsians more so with basally located depressions on both sides of the primary ridge and a roughly mesiodistally oriented cingulum. We propose that the teeth belong to either a ceratopsoid or ceratopsid based on the bifid tooth roots. Teeth belonging to a derived ceratopsian in the Santonian of Appalachia implies two things. First, the transgressions and regressions of interior seaways allowed for pulses in

ceratopsian migrations from Laramidia to Appalachia. If so, then derived ceratopsians would have been present in Appalachia up to 17 million years prior to what previous literature suggests. Secondly, the rarity of large-bodied ceratopsians in Appalachian marine deposits suggests that if the animals were present throughout the Late Cretaceous, then it is most likely that their biogeographical range was consistently restrained to hinterlands rather than nearshore environments – as has been suggested in previous literature.

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Virtual Posters

**AN EXAMINATION OF GOMPHODONT MATERIAL FROM THE *CYNOGNATHUS* ASSEMBLAGE ZONE OF THE BURGERSDORP FORMATION OF SOUTH AFRICA AND THE IDENTIFICATION OF THREE NEW SPECIES, WITH POTENTIAL IMPLICATIONS ON STRATIGRAPHICAL CORRELATIONS**

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The Burgersdorp Formation of South Africa is a richly fossiliferous rock sequence at the top of the Permian–Triassic Beaufort Group and is known for its abundance of Early–Middle Triassic vertebrate remains, particularly cynodonts. Fossils from the Burgersdorp Formation are referred bio-stratigraphically to the *Cynognathus* Assemblage Zone (CAZ), which is further divided into three subzones: *Langbergia-Garjainia, Trirachodon-Kannemeyeria*, and *Cricodon-Ufudocyclops.* Each subzone is characterized by the presence of a distinct species of trirachodontid, a group of gomphodont cynodonts found relatively abundantly throughout the CAZ, with the lower two subzones characterized by the medium-sized trirachodontids *Langbergia* and *Trirachodon*. The uppermost part of the formation, the *Cricodon-Ufudocyclops* subzone*,* yields trirachodontids of larger size. Most of these specimens have previously been referred to *Cricodon metabolus*, a taxon also known from the Manda Beds of Tanzania and the Ntawere Formation of Zambia. Pivotal conclusions have been drawn about stratigraphical correlations between these formations, partially based on this taxonomic referral.

Identification of these specimens as three new taxa will be presented; the already formerly described and named *Guttigomphus avilionis,* a novel genus; a new species of the traversodontid *Impidens;* and a new species of *Cricodon.* No occurrence of *C. metabolus* is currently documented from the Burgersdorp formation, and the implication of this finding on faunal assemblage correlations is considered. This project will present the distinguishing features of postcanine morphology that are the primary basis for differentiation of the new taxa and other closely related gomphodonts, along with a discussion of phylogenetic uncertainty among these taxa.

**Funding Sources** Funding for field work was provided by a Marie Curie Career Integration Grant (630123), the NRF African Origins Platform (98800) and Palaeontological Scientific Trust.

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**DENTAL ANATOMY, DEVELOPMENT, REPLACEMENT, AND THE EVOLUTION OF MAMMALIAN FEATURES AS EVIDENCED BY THE LATE PERMIAN ANOMODONT *SUMINIA***

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Mammalian chewing and related features have been one of the most widely discussed vertebrate evolutionary innovations. The features most often studied involve the evolutionary transition of the jaw joint from the quadrate and articular to the mammalian joint composed of the squamosal and dentary, the evolution of regionalized dental heterodonty and the evolution of the tribosphenic molar system within the context of precise occlusion in crown mammals. However, the complex, gradual acquisition of a host of mammal-like features within the Paleozoic that can be associated with mammalian feeding behavior have been largely ignored. Here we report on the dentition and jaw system in the small anomodont *Suminia* from the late Permian of Russia. This small arboreal herbivore is known from numerous articulated skeletons and isolated skulls and jaws, allowing us to employ various methods of investigation including synchrotoron computed tomography and histology. Although *Suminia* is posited to be deep along the mammalian stem, our multidisciplinary investigations found that it possessed a number of mammalian dental innovations. Notable among these is the presence of true thecodonty and gomphosis, an increase in dental longevity, and apparent reduction in tooth replacement to two cycles. The latter has resulted in having the functional teeth ground to small nubbins that have exposed their pulp cavities. Most surprisingly, however, there is clear evidence that the replacement teeth form deep beneath the functional teeth, providing the oldest known instance that the dental lamina having migrated into the jaw bone. This is in contrast to other Paleozoic and Mesozoic reptiles where there is thecodonty, or gomphosis, or both, but the teeth start to develop lingually and migrate secondarily into the jaw bones through small openings. The pattern of tooth wear on various surfaces of the functional teeth also provides clear evidence of a complex pattern of jaw movement, and the occluding dentition and the reconstructed jaw adductor musculature, in combination with an open jaw joint, would have facilitated mechanical breakdown of a variety of plants. In addition, this complex craniodental system also could accommodate changing dental geometry resulting from tooth wear.

**Funding Sources** NSERC (Canada); Jilin University (China)

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Technical Session 10: Euarchontoglires & Xenarthra (Friday, October 20, 2023, 8:00 AM)

### OLD PROBLEMS REQUIRE MODERN SOLUTIONS: 3D TOOTH TRAITS UNVEIL *REITHRODONTOMYS* SPECIES PALEOECOLOGY

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After the Pleistocene, micromammals survived global warming and trophic downgrading through both ecological adaptations and geographic range shifts. As similar stressors threaten modern communities, we can demystify future responses by studying the recent rodent fossil record. Such paleoecological studies often include fossilized rodent teeth and jaws, but ambiguous species-level identifications complicate interpretations. Here, we develop dental identifications to test whether *Reithrodontomys* harvest mice experienced species turnover or adapted in situ *o*ver the last 22,000 years at Hall's Cave in Texas. Three species (*R. fulvescens, R. megalotis, and R. montanus*) occur near the site today, and differ in diet and habitat. We microCT-scanned complete lower tooth rows of fossilized Hall's Cave *Reithrodontomys* (n=91) and modern museum specimens (n=16) trapped nearby to diagnose these three species from dental traits and characterize their stratigraphic distribution in the Hall's Cave record. Following dental nomenclature found in literature, *Reithrodontomys* descriptions, and our comparative collection, we determined the m1 anterolophid, m3 major fold, m3 metaconid, and m3 enamel ridge morphology as diagnostic to the species level. >40 previously published radiocarbon dates confer precise ages to specimens of known depth per a spline-based age-depth model. We identified all microCT-scanned *Reithrodontomys* from the Hall's Cave record and we documented the first *R. megalotis* at the site. We found the three species together within four 5 cm strata in the late Holocene, early Holocene, terminal Pleistocene, and late Pleistocene. We found the dental traits much more identifiable in high-resolution 3D models than photographs, and we have confidently identified 55 fossilized Hall's Cave *Reithrodontomys* to the species level so far. Thus, we provide a novel method to identify *Reithrodontomys* species in the fossil record. Co-occurrence throughout the record suggests that each species adapted to the changing ecosystem rather than being replaced by geographically adjacent species, and continuing identifications may reveal finer scale occupancy patterns. Our results show that microCT-based identifications can confer greater specificity to micromammal paleoecological studies and show that some sympatric, congeneric micromammal species can adapt to climate change and biodiversity loss in situ.

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Technical Session 8: Mammal Paleoecology (Thursday, October 19, 2023, 1:45 PM)

### OREGON OLIGO-MIOCENE HERBIVORE COMMUNITY NICHE PARTITIONING: SYNTHESIS AND INSIGHTS FROM STABLE ISOTOPE ANALYSIS

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During the Oligo-Miocene (~30 -5 Ma), the world saw global expansion of open habitats. Fossil collections throughout this interval indicate ungulate ecological diversity decreases coincided with shifts in vegetation and climate. Extant species-rich herbivore assemblages indicate that partitioning of food resources lowers interspecific competition and allows for higher diversity. The Mid-Miocene Climatic Optimum (MMCO, ~16 Ma) was characterized by warm temperatures, and exhibits exceptionally high herbivore diversity, hypothesized to have been driven by high productivity and niche partitioning. Oregon fossil assemblages spanning the time before and after the MMCO, are ideal for understanding past ungulate diets and how niche partitioning changed as ungulate diversity fell. We compiled previously published stable isotopic records for Oregon and obtained new stable carbon and oxygen isotopic measurements from fossil tooth enamel (n = 92 of 20 species). New samples are from the Turtle Cove Member of the John Day Formation (~31-25 Ma), the Mascall Formation (~17-12 Ma), and the Rattlesnake Formation (~8-7 Ma). To reconstruct resource partitioning and niche breadth, we compared ungulate estimated body masses and tooth morphology to the distribution of their isotopic values. Isotopic evidence, morphology, and body mass indicate a more homogeneous herbivore community arose as grasslands spread in Oregon. We find evidence for dietary niche partitioning within ungulate communities in the late Oligocene to mid Miocene. Different species were likely either eating plants in different microhabitats or consuming different plant species or parts. Small browsing ungulates, most of which had narrow isotopic niches, were lost and are not present in the late Miocene of Oregon. Interestingly, we find evidence that *Ticholeptus* (a mid-Miocene oreodont species) has a wider isotopic niche compared with earlier oreodonts (e.g., *Eporeodon*). This result indicates that it had adapted to eating a wider variety of foods, or in a variety of habitats, in the heterogenous landscape that existed during the MMCO. Our work shows that just as in the Great Plains, during the Oligo-Miocene Oregon ungulate communities transitioned from a diverse group that partitioned plant resources to one that had fewer species with similar morphologies and stable isotopic values. This project broadens our knowledge of changes in ungulate ecological diversity, resource partitioning, and niche breadth.

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

## THE SKELETAL MORPHOLOGY OF A HYPOTHETICALLY JUVENILE AETOSAUR SPECIMEN FROM THE LATE TRIASSIC DOCKUM GROUP (OTISCHALKIAN) OF TEXAS

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The Aetosauria is a speciose clade of archosaurs documented from continental upper Triassic strata. Most of the documented taxa are known exclusively from the Late Triassic Chinle Formation and Dockum Group in the southwestern United States. Few articulated and partially complete skeletons of aetosaurs have been collected from the Dockum Group in northwestern Texas and eastern New Mexico including those of *Calyptosuchus wellesi*, *Typothorax coccinarum*, and *Coahomasuchus kahleorum*. Here, we present an articulated and relatively complete skeleton of an aetosaur from the Otischalk locality in Howard County, Texas. The specimen was originally collected in the 1940’s as part of collection efforts by the Works Progress Administration and is now housed within the Texas Vertebrate Paleontology Collections at UT Austin. This specimen (TMM 31100-1336) preserves both an articulated skull and precaudal region that are intermixed with other bone fragments and matrix. CT-imaging indicates that the preserved vertebrae lack co-ossification between the centra and their respective neural arches which suggests that TMM 31100-1336 represents a skeletally immature individual. Additionally, its small body size suggests that the individual is a juvenile. Elements of the cranium, mandible, carapace, vertebral column, and shoulder and pelvic girdles were segmented. Homologous elements were compared with *Longosuchus meadei, Lucasuchus hunti*, and *Coahomoasuchus kahleorum*, which are also documented within the same locality, in order to assess the taxonomic affinities of TMM 31100-1336. The recurved dentition, morphology of the maxilla, mandible, parabasisphenoid, basioccipital, and lateral

and paramedian osteoderms, suggests that TMM 31100-1336 represents a juvenile individual referrable to *Coahomasuchus kahleorum*. Following this taxonomic referral, TMM 31100-1336 suggests that lateral osteoderms do not undergo drastic morphological change in their flexure through skeletal maturity, but instead grow proportionately larger. Additionally, CT-imaging shows that the juvenile specimen TMM 31100-1336 is intermixed with elements, particularly of the skull, from at least three other individuals that are of similar size and identical in morphology. This suggests that TMM 31100-1336 preserves several hypothetically juvenile individuals referrable to *Coahomasuchus kahleorum*. This is only the second report of a locality preserving several juvenile individuals of a particular aetosaur taxon.

**Funding Sources** NSF-EAR-1762458; NSF Graduate Research Fellowship Program (No. 2137420); Lundelius Endowement in Vertebrate Paleontology

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Technical Session 12: Methods & Paleohistology (Friday, October 20, 2023, 8:00 AM)

**MULTIVARIATE ADAPTIVE LANDSCAPES WITH QUADRATIC REGRESSION**

Rhoda, Daniel, Angielczyk, Kenneth D.

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Recently it was demonstrated that multiple performance surfaces can be combined into a type of adaptive landscape by iteratively weighting and combining performance surfaces until a solution is found that maximizes the 'height' at which empirical data points rest on the combined surface. Assuming selection is the primary influence on the distribution of species in morphospace, this combined surface represents an adaptive landscape and can be used to predict the evolutionary trajectories lineages would take under selection for the combination of functions considered. This approach has piqued interest in the paleontological community because adaptive landscapes can now be readily computed directly from phenotypic data, and it has already been adopted to address major evolutionary transformations in the fossil record, such as the water-land transition in tetrapods and the 'lateral-to-sagittal' model of mammalian vertebral evolution. However, the choice of method used to compute performance surfaces has not been consistent across analyses. Here, we argue that quadratic (2$^{nd}$-degree polynomial) regression is the most suitable approach for the computation of performance surfaces and the eventual adaptive landscapes derived from them. We show that the quadratic regression coefficients directly correspond to different types of selection (e.g., directional, stabilizing), and that the entire multivariate trait space can be incorporated in the analysis, rather than a subset of axes (often just two), allowing paleontologists to realize the multidimensional adaptive landscape envisioned by G.G. Simpson. We then compare quadratic regression to another popular method, Kriging interpolation, with both simulated and empirical examples. Our preliminary results suggest Kriging produces unrealistically rugged surfaces in both controlled simulations and in well-studied empirical examples, and that this ruggedness may be exaggerated when combining performance surfaces. Further, the information lost by only including a subset of phenotypic axes can have consequential effects on the interpretation of results.

**Funding Sources** University of Chicago's Hinds Fund for Graduate Research, NSF Graduate Research Fellowship Program

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**INSIDE AN ICON: NEW INFORMATION ON THE SKULL AND RELATED ANATOMY OF THE *ALLOSAURUS JIMMADSENI* (DINOSAURIA: THEROPODA) SPECIMEN KNOWN AS "BIG AL" (MOR 693) BASED ON NEW CT SCANNING**

Rhynard, Peter, Stricklin, Maranda, Ridgely, Ryan, Witmer, Lawrence M.

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Evolutionary biology has benefited from the use of "model organisms"—that is, species (e.g., *Drosophila*, *C. elegans*, zebrafish, mouse) receiving extensive scientific attention with the expectation that knowledge gained will extend to less-studied species. Among dinosaurs, the Late Jurassic Morrison Formation theropod *Allosaurus* is a candidate for such status given the abundance of specimens and almost 150 years of scientific study. Moreover, its generalized body plan, phylogenetic position, and popular appeal justify continued study. Here we present new studies of perhaps the most famous and most studied single specimen, known as "Big Al" (MOR 693), an almost complete skull and skeleton referred to *A. jimmadseni*. The skull was first subjected to computed tomographic (CT) scanning in the 1990s but was rescanned for the first time since then in December 2022, providing an excellent, higher-resolution dataset. The Big Al project is a long-term study involving segmentation and restoration of all bones and the whole skull, segmentation of enclosed air sinus spaces and neurovascular canals, and more or less complete restoration of cephalic soft tissues. This presentation focuses on work to date that includes both largely complete studies (e.g., the brain endocast and endosseous labyrinth) and more proof-of-concept studies (e.g., segmentation and digital extraction of the lacrimal bone and enclosed pneumatic sinuses; pneumatic chambers of the maxilla). The brain endocast is largely complete and resembles that of most allosauroids in being markedly flexed but not strongly reflecting underlying brain structure other than the cerebral hemispheres, floccular lobes of the cerebellum, and pituitary. The MOR 693 endocast is compared to endocasts our team has generated from isolated Cleveland-Lloyd Dinosaur Quarry braincases that have been referred to *A. fragilis*, although the present sample does not allow definitive discrimination of inter- and intraspecific variation. Segmentation of the lacrimal cavities reveals multichambered pneumatic cavities within the crest. Likewise, the CT data reveal paper-thin septation of the promaxillary recesses of the maxilla, structures that typically are lost in isolated specimens. Indeed, the benefit of these separate more focused studies is that they all can be integrated within the complete skull of a single individual known from a full skeleton, moving forward efforts to "flesh out" the anatomy of this model organism.

**Funding Sources** US National Science Foundation: NSF IOB-0517257, IOS-1050154, IOS-1456503; Swedish Research Council: SRC 2021-02973; OU Heritage College of Osteopathic Medicine

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Technical Session 21: Squamates (Saturday, October 21, 2023, 1:45 PM)

**EARLY MIOCENE SNAKES FROM FLORIDA AND A REASSESSMENT OF NORTH AMERICAN FOSSIL BOINES**

Riegler, Mitchell, Viñola-López, Lazaro W., Vallejo-Pareja, Maria C., Bourque, Jason R., Bloch, Jonathan I.

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The oldest fossils referred to Boinae in North America have received multiple taxonomic interpretations over the last few decades, primarily based on vertebrae from the early Miocene (Hemingfordian, 17-18 Ma) Thomas Farm locality of Gilchrist County, Florida. Initially, two species of the extinct boid *Nuerodromicus* were recognized in this sample. However, with improved understanding of the boine fossil record in South America and comparative work highlighting inter- and intraspecific variation, these vertebrae have been reclassified as *Psuedoepicrates*, *Boa*, and most recently, *Chilabothrus*. Competing taxonomic assignments infer significantly different biogeographic dispersal scenarios for these early North American boines. For example, *Boa* suggests a South American origin while *Chilabothrus* suggests a Caribbean origin. Annual public fossil digs, focused screenwashing, and a recent emphasis on microfossil curation has substantially increased the number of fossil snakes from Thomas Farm including hundreds of vertebrae and the first recovered dentary. Comparative morphology using images generated from X-ray computed microtomography (µCT) of the new fossils and extant boine taxa (*Boa*, *Chilabothrus*, *Corallus*, *Epicrates*, *Eunectes*) strongly suggests the presence of at least one species best classified as *Boa*. A suite of characters has been used to identify vertebrae to the genus *Boa*, including: 1) a straight, posteromedially angled interzygapophyseal ridge, 2) well-developed paracotylar foramina within deep fossae, 3) a tall neural spine, and 4) a tall, thickened zygosphene. While none of the vertebrae from Thomas Farm exhibit all these characters, the new dentary has several features indicative of the genus *Boa* supporting a South American origin for this early North American boine. This record likely represents the northernmost occurrence of a South American clade prior to the closure of the Isthmus of Panama and the Great American Biotic Interchange (GABI). Additionally, comparisons with contemporaneous early Miocene fossils from the Panama Canal previously referred to *Boa* show some differences in vertebral morphology, suggesting the possibility of latitudinal variation or the presence of more than one lineage at that time. Newly documented variation in vertebral morphology from Thomas Farm suggests that a smaller non-boine taxon was also present in addition to those larger specimens referred to *Boa*, possibly contributing to the ambiguity of previous studies.

**Funding Sources** All funding was provided by NSF (DBI-1756306) to JIB.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

### FIRST CRANIUM OF THE ENIGMATIC ARCHAIC UNGULATE MAMMAL *'CARCINODON'* IN THE DENVER BASIN, COLORADO, PROMPTS REEVALUATION OF THAT GENUS

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Archaic ungulates (i.e., 'condylarths') epitomize the ascendancy of mammals in the aftermath of the Cretaceous-Paleogene (K-Pg) mass extinction due to abundance and diversity in the early Paleocene. Nonetheless, their taxonomy is problematic due to their generally fragmentary fossil record, which comprises mostly isolated teeth and jaw fragments, and their broadly similar and plesiomorphic dental morphologies. Recently, in early Paleocene exposures in the Denver Basin just east of Colorado Springs, Colorado (Corral Bluffs), exceptionally preserved mammal skulls have been discovered, providing fresh insights into the taxonomy and paleobiology of early archaic ungulates. Here we report the discovery of a mammalian cranium that is almost complete, with a maxilla including almost all premolars and all molars on both sides (DMNH EPV.132501). We assign this skull to *'Carcinodon'* based on (1) P3 length exceeding its width, (2) P3 protocone being absent, and (3) P4 parastylar lobes being buccolingually narrow and roughly parallel, thus representing the first occurrence of that genus in the Denver Basin. The upper dentition closely resembles that of *'Carcinodon' olearyi* based on the: (1) prominent hypocones on M1–M2, (2) prominent lingual cingulum continuous with precingulum and hypocone shelf on M1–M3, (3) metacone shifted lingually relative to the paracone on M2–M3, (4) similar size (M2 length = 6.10 mm), (5) hypocone extends lingually past the protocone apex on M1, and (6) parastylar lobe on M3 extends much farther buccally relative to the metastylar lobe. Species of *'Carcinodon'* have been variably placed in the genera *Chriacus*, *Baioconodon*, and *Oxyclaenus*, all of which exhibit relatively plesiomorphic dentitions. Nevertheless, our study of the nearly complete dentition of *'C.' olearyi* supports the hypothesis that *'Carcinodon'* is polyphyletic. As such, we propose that *'C.' olearyi* and *'C.' antiquus* represent a new genus separate from genotypic species, *C. simplex*, that is phylogenetically basal to *Oxyclaenus*, *Eoconodon*, and *Triisodon*, and all of their descendants. Recognition of this new genus clarifies phylogenetic relationships among early Paleocene 'arctocyonids'. Further, DMNH EPV.132501 represents the first cranial remains of this taxon and for any other 'oxyclaenid-like' archaic ungulate. Study of its cranial anatomy is ongoing but will hopefully illuminate cranial autapomorphies that help further differentiate early archaic ungulates.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

### PHYLOGENY OF DINOMYIDAE RODENTS (RODENTIA, CAVIOMORPHA) FROM THE MIOCENE OF NORTHEN SOUTH AMERICA

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Dinomyidae is a family of big rodents from South America, with body sizes ranging from a few kg to 1200 kg. Their fossil record in South America begins in the middle Miocene, reaches a relatively high diversity during the late Miocene and progressively decreases during the Pliocene and Pleistocene. Dinomyidae is currently subdivided into four subfamilies: Potamarchinae, Dinomyinae, Eumegamyinae, and the Tetrastylinae. This work explores the phylogenetic affinities of the Dinomyidae from the Miocene of northern South America based on the morphology of occlusal surface of molars. 118 characters (63 ordered) and 38 taxa were used. Data were analyzed by TNT 1.1 software using: maximum parsimony, characters with equal implicit weight, 1000 replicates with 'traditional search option', 'tree bisection reconnection' (TBR) exchange algorithm, ten trees saved per replication, and collapsing trees after each search. This analysis recovered two most parsimonious trees. The strict consensus tree (consistency index=0.349; retention index=0.600) shows the Dinomyidae as a monophyletic group supported by five

synapomorphies: direction of the buccal part of the posterior arm of the protoconid clearly oblique and extending backwards; metalofulid II short and connected to the metaconid; hypolophid short; anterior arm of hypoconid absent or secondarily missing = Taeniodont condition; entoconid anterior to hypoconid. Some of the Dinomyidae analyzed, cf. *Olenopsis* sp., *Scleromys colombianus*, and *Scleromys schurmanni* (middle Miocene, Colombia), *Drytomomys aequatorialis* (Miocene, Ecuador), and a new Dynomyidae from the early Miocene (17.21 to 19.27 Ma) of Venezuela are grouped by a synapomorphy: posterior arm of the metaconid in the p4 well developed, tall and long. The taxa *D. aequatorialis* and cf. *Olenopsis* sp. are closely related, but evidently represent two different taxa, due to the number of different synapomorphies. *S. colombianus* and *S. schurmanni* are not closely related to *Scleromys osbornianus* from the Early Miocene of Argentina and clearly represent different lineages. *S. colombianus*, *S. shurmanni*, and the new Dinomyidae remains from Venezuela differ from the rest of the Dinomyidae by having strongly oblique transverse ridges on their molars. The analysis suggests that *Incamys bolivianus* is a dinomyid, whereas *Branisamys luribayensis* is a basal lineage to Dasyproctidae-Dinomyidae clade.

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Technical Session 11: Archosaurs (Friday, October 20, 2023, 8:00 AM)

**NEW ARCHOSAURIFORM RECORDS FROM THE MARINE EARLY TRIASSIC OF SVALBARD**

Roberts, Aubrey J.[1], Foffa, Davide[2], Kear, Benjamin[3], Hurum, Jørn[1]

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The Permian-Triassic Mass Extinction (PTME) was the most severe mass extinction evidenced from the fossil record. This event caused dramatic ecosystem change and restructuring, as proven by the emergence of drastically transformed terrestrial and marine faunas in the Early Triassic. This includes the initial invasion of oceanic habitats by aquatic reptiles, such as ichthyosaurs, sauropterygians, thalattosaurs and archosauriforms. However, examples of the earliest Mesozoic marine reptile assemblages are globally rare, which hinders understanding of the early evolution, biogeography, and diversification of these pioneering pelagic clades. Some of the most famous Early Triassic marine reptile faunas are documented from the Lower Triassic (Olenekian) Vikinghøgda Formation on the island of Spitsbergen in the Norwegian Arctic Svalbard archipelago. At the time of deposition, this region formed part of an embayment bordering northern Pangea, and thus represents an important paleogeographic region connecting the eastern Tethys and western Panthalassan margin of North America. Recent field exploration on Spitsbergen has revealed highly fossiliferous strata containing chondrichthyan, actinopterygian, sarcopterygian, temnospondyl, and marine reptile remains. Of these, the informally designated '*Grippia* bonebed' horizon is a particularly diverse and condensed multi-taxa micro- and macro- assemblage. Although, demonstrably marine, the presence of worn lungfish tooth plates attributable to *Ceratodus* suggest a proximity to brackish or freshwater environments. Likewise, the historical identification of an isolated archosauromorph vertebra in 1918 was compared with terrestrial forms. By contrast, subsequent recognition of over 50 individual vertebrae, ilia, and limb bones representing multiple individuals and size classes of archosauromorph indicates affinity with semi-aquatic archosauriformes, particularly *Vancleavea campi* and *Litorosuchus somnii*, which share key character states in the cervical and caudal vertebrae and ilia. Fully or semi-aquatic archosauriforms are therefore unambiguously present in the '*Grippia* bonebed', and likely reflect at least a single novel taxon based on taphonomy and the presence of multiple ontogenetic morphs. Ultimately, our survey reveals that diverse vertebrate assemblages, including aquatic archosauriforms, were established in the northern Boreal embayment of Pangea already in the Early Triassic.

**Funding Sources** Fieldwork on Svalbard during 2014–16 was funded by Spitsbergen Travel, National Geographic (grants GEFNE158–15; GEFNE 108–14), Bayerngas Norge, Tullow Oil and CGG.

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Technical Session 9: Sauropsids (Thursday, October 19, 2023, 1:45 PM)

**DIVERGENT EVOLUTIONARY HISTORIES IN THE EVOLUTION OF AXIAL SKELETAL COMPLEXITY BETWEEN REPTILES AND MAMMALS**

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The axial skeleton is divided into discrete regions identified by morphology and function. Independently from regionalization, the amount of morphological variation between all elements varies, referred to as the degree of intracolumnar heterogeneity. Both regionalization and heterogeneity contribute to functional diversity of the axial skeleton. This relationship is well understood across pan-Mammalia but is poorly understood for Reptilia. We combine 3D geometric morphometrics with maximum likelihood model testing to determine regionalization and heterogeneity of the vertebral column of 90 reptiles, and representative mammal and amphibian taxa. We test for relationships between axial skeleton diversity, phylogeny, body size, and ecology using phylogenetic comparative methods, evolutionary modelling, and the integration of recent and fossil data. We model four regions in all mammals and most reptiles, regardless of body size or ecology. We find that most diversity in intracolumnar heterogeneity in reptiles is directly linked to body size. Small-bodied lepidosaurs possess low heterogeneity and large-bodied archosaurs possess high heterogeneity, despite low regionalization. Inversely, across pan-Mammalia increased complexity is associated with the evolution of small body sizes. We suggest that in reptiles larger body sizes impart more heterogeneously distributed biomechanical stresses on the axial skeleton, which increases overall vertebral complexity. Volant birds are the only reptiles that have more complex vertebral anatomies than expected based on body size, suggesting a different driver of complexity compared to other reptiles. Birds have strongly differentiated cervical and thoracic regions which contributes largely to high heterogeneity scores across the clade. This reflects functional differentiation of the axial skeleton to accommodate specialist respiratory function and powered flight. Evolutionary patterns for birds are similar to those established across pan-Mammalia, where increased heterogeneity corresponds with functional differences between axial regions associated with high aerobic requirements for endothermy. The establishment of endothermy in stem mammals potentially necessitated a high intracolumnar heterogeneity regardless of body size. Divergent patterns of axial skeleton evolution between reptiles and mammals reflect divergent drivers and constraints associated with body form evolution and physiological adaptations.

**Funding Sources** NERC Studentship to LER

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Technical Session 5: Ungulates (Wednesday, October 18, 2023, 1:45 PM)

**BASAL CAMELIDS: AUDITORY REGION MORPHOLOGY AND PHYLOGENETIC IMPLICATIONS**

Robson, Selina Viktor, Theodor, Jessica

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Camelids are a North American radiation that represent the only definitive tylopods. Several extinct artiodactyl families have also been referred to Tylopoda, and Tylopoda might be more diverse than Ruminantia. However, hypotheses about the composition of the suborder have not been directly tested using modern phylogenetic methods. The morphology of the auditory region has recently been used in phylogenetic analyses as a semi-independent line of evidence, but the auditory morphology of basal camelids and their likely sister group—the oromerycids—remains understudied. To build a more robust dataset for testing tylopod relationships, we used CT scanning to image the auditory region of select oromerycids (*Protylopus*, *Eotylopus*) and basal camelids (*Poebrotherium wilsoni, ?Poebrotherium franki*, *Pseudolabis*, *Miotylopus*, *Stenomylus*). We reconstructed the petrosal and bony labyrinth morphologies of these taxa and incorporated characters from the auditory region into a matrix of dental and cranial characters. We then conducted a parsimony analysis to test the hypothesized relationships of basal camelids.

Our analyses recovered a non-monophyletic Camelidae, with *Poebrodon kayi* placed within Oromerycidae. The genus *Poebrotherium* is also non-monophyletic; notably, *Poebrotherium chadronense* is recovered as the most basal camelid (excluding *P. kayi*). These relationships have poor support and may change with additional data. Conversely, the Stenomylinae are strongly supported as monophyletic. All oromerycids and camelids have a stereotyped bony labyrinth with a cochlea averaging 3 turns, a large anterior semicircular canal, and a small lateral semicircular canal. Excluding *P. kayi*, camelids are united by a diastema between the two rostral-most premolars, a maxillary fossa, pronounced orbital roofing, and a tympanic bulla strongly in contact with the paroccipital process.

They also have a pronounced rostral tympanic process and ventromedial flange on the petrosal. *Protylopus* has what might be an incipient ventromedial flange, and *Eotylopus* has a small but definitive flange; this may prove informative for broader tylopod relationships. The stenomylines are united by several synapomorphies, including a prominent anterior process of the tegmen tympani and a relatively small internal acoustic meatus. These results represent an important step towards testing hypothesis about camelid and tylopod evolution and resolving relationships within the clades.

**Funding Sources** NSERC Discovery Grant

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

### IDENTIFICATION OF THE PUSH CREEK FAUNA, A MIOCENE FAUNA FROM EAST TEXAS

Rock, Andrew A., Godwin, William, Lewis, Patrick J.

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Push and Rush Creeks are a pair of interconnected creeks that make up a paleontological locality in Tyler County, Texas. The Push/Rush Creeks locality (PRC) is located north of the Big Thicket National Preserve and east of Woodville, Texas. The PRC cuts through a vertebrate fossil rich portion of the Lagarto Formation, a subdivision of the Fleming Group, dated to ca. 14-12 mya. Over a thousand fragmentary fossils collected from PRC are housed at the Sam Houston State University Natural Collections (NHC). Prothero examined rhinoceros specimens from the PRC, but a complete survey of the fauna is lacking. The project presented here will identify all specimens collected from the PRC and housed in the NNC to the lowest taxonomic level. Identifications are based on physical characters, including both qualitative (e.g. general shape and texture, presence and absence of features) and quantitative (e.g. length, width, and thickness of structures). Characters are compared with previously identified Miocene specimens housed at The Texas Vertebrate Paleontology Collections at The University of Texas at Austin and by using published descriptions of fossils from nearby sites in the Fleming Group, such as the Toledo Bend Reservoir locality and the Cold Spring locality. Those localities represent the early and late depositional environments of the Lagarto Formation. To date, 124 specimens are identified to at least the Family level, including six orders of vertebrates (Testudines, Rodentia, Crocodilia, Proboscidea, Artiodactyla, and Perissodactyla). Miocene deposits record dramatic changes in the environment and fauna of North America, such as the spread of grasslands, a radiation of Equids, and a change in sea level. A more complete recording of the fauna preserved at the PRC locality will, therefore, allow for a fuller understanding of these events across the continent. Comparing the depositional environments of the Miocene localities in East Texas will also better define the Texas coastline during and after the Miocene Thermal Maximum. In addition, a comprehensive taxonomic list for the PRC will help define the relationships of the PRC fauna and help clarify the distribution of taxa during the middle Miocene of Texas.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

### THE FIRST KNOWN CERVICAL VERTEBRAE OF AN OMOMYOID PRIMATE, *SHOSHONIUS COOPERI*, AND THEIR BEARING ON TARSIER, ANTHROPOID, AND HAPLORHINE RELATIONSHIPS

Rodwell, Ben

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Unlike most omomyoid primates, which are overwhelmingly known only from dento-gnathic remains, *Shoshonius cooperi* is also known from postcranial material and multiple fossil crania. Cranial specimens of *Shoshonius* demonstrate that it differs from other omomyoids in exhibiting extreme orbital hypertrophy like that of extant tarsiers. This orbital hypertrophy and other shared cranial characters (e.g., a vertical nasolacrimal canal, a ventrolaterally located posterior carotid foramen, and basioccipital flange overlapping the auditory bulla) have been argued to support a close phylogenetic relationship between *Shoshonius* and tarsiers to the exclusion of other omomyoids. However, tarsiers and anthropoids share derived cranial features (e.g., contact between the alispehenoid and zygomatic bones to form a postorbital septum, reduction or loss of the stapedial artery and canal, a perbullar pathway for the internal carotid artery, and loss of ethmoturbinals III-IV) that are not present in

*Shoshonius*, suggesting that *Shoshonius* may instead be a stem haplorhine. Postcranially, *Shoshonius* lacks derived features of tarsiers associated with their vertical clinging and leaping locomotor repertoire, including elongation of the calcaneus and navicular and fusion of the tibia and fibula. Here we describe the first known cervical vertebrae of *Shoshonius cooperi*, the axis (C2), and two lower cervical vertebrae. These are the first described cervical vertebrae of any omomyoid, and they reveal that the cervical spine of *Shoshonius* more closely resembles that of quadrupedal lemuriforms than that of tarsiers. Notably, C2 of *Shoshonius* has a mediolaterally compressed and craniocaudally elongated 'paddle' shaped spinous process that resembles that of cheirogaleid lemuriforms, while the spinous process of C2 of tarsiers is much smaller and craniocaudally compressed. Significantly, the lower cervical vertebrae of *Shoshonius* have zygapophyses that are oriented intermediate to the transverse and coronal planes, resembling those of cheirogaleids and other lemuriforms. By comparison, the zygapophyses of tarsier lower cervical vertebrae are oriented subparallel to the transverse plane; most likely an adaptation for high rotational mobility of the neck. The morphology of the cervical spine in *Shoshonius* adds additional support for the hypothesis that *Shoshonius* is more likely a stem haplorhine than a stem tarsiiform.

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**DIETARY ECOLOGY OF EXTANT MARINE MAMMALS CAN BE INFERRED FROM DENTAL MICROWEAR TEXTURE ANALYSIS**

Rogers, Ashley, Johnson, Solathus, DeSantis, Larisa

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Dental microwear texture analysis (DMTA) has clarified the dietary ecology of extant and extinct species over the past 20 years, with a focus on terrestrial organisms. The main goal of this study is to assess the effectiveness of DMTA as a tool to interpret diets of the common bottlenose dolphin (*Tursiops truncatus*), orca (*Orcinus orca*), beluga whale (*Delphinapterus leucas*), walrus (*Odobenus rosmarus*), sea otter (*Enhydra lutris*), and sperm whale (*Physeter catodon*). Our preliminary results indicate that marine mammals such as sea otters, beluga whales, walruses and sperm whales eat significantly harder foods (with higher complexity, Asfc values) than the primarily fish consuming common bottlenose dolphin and orca. Additionally, there is little to no evidence that orcas, with the lowest Asfc values, are durophagous (i.e., eating hard foods). There is clear evidence that dolphins and orcas are consuming softer foods than the remaining taxa—which are known to eat a range of organisms including fish and invertebrates such as crustaceans and mollusks. Consequently, we found that dental microwear may be an effective tool to analyze the diets of extant and potentially extinct marine mammals, as the surface textures on their teeth correspond with observed diets. Dental microwear texture analysis may also allow us to better understand the effects of climate change on marine mammal diets and may be used to track dietary changes in marine mammals via the analysis of historic specimens. Most notably, DMTA may be useful at understanding the terrestrial to marine transition in marine mammals—expanding on our understanding of their ecology over time.

**Funding Sources** Vanderbilt University; National Science Foundation; NIH/NIGMS Program through grant T34GM136451.

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Virtual Posters

**COULD *SMILODON* CLIMB TREES?**

Roriz, Livia[1], Dantas, Mário[2]

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Some living large felines have the ability to climb trees because of their flexible joints, but there are still no studies that suggest whether *Smilodon fatalis* Leidy, 1869 and *Smilodon populator* Lund, 1842 possess the same ability. These were two of the largest felines in the Pleistocene of South America inhabiting low-density forests and arboreal savanna habitats. Therefore, the objective of this study was to evaluate this possibility through morphological analyses of the ulna using the index of dorsal projection (IDO) of the olecranon in association with its body mass. Based on data from the primate and xenarthran taxa, animals with suspensory or climber habits present IDO values varying between 0.52 to 1.24, being separate as suspensory based on the body mass log-transformed varying between 0.68-1.30 (bm = 5-20 kg), and climbers with body mass log-transformed varying between 1.70-2.40 (bm = 50-250 kg). A taxon that has a body mass log-transformed higher than 2.40 (bm > 250 kg) should be terrestrial. Analyzed individuals came from the Laboratório de Ecologia e Geociências/UFBA (LEG) and figured in the literature from Brazil, Ecuador, and the USA: one adult specimen of *Panthera onca* (LEG 1066, bm = 104 kg); one subadult (LEG 2261, bm = 185 kg) and three adult (MZSP-PV 05, bm = 448 kg; MCL 7157, bm = 365 kg; MCL 7187, bm = 286 kg) specimens of *Smilodon populator*; one subadult (ROMVP 5109, bm = 214 kg) and two adult (ROMVP 5108, bm = 219 kg; 2007-R-6, bm = 228 kg) specimens of *Smilodon fatalis*; and one adult specimen of *Panthera atrox* (2905-R-8, bm = 289 kg). The IDO results (*P. onca*, 0.69; *S. fatalis*, subadult 0.88 and adults 0.75-0.80; *S. populator*, subadult 0.67 and adults 0.80-1.05; *P. atrox*, 1.07) show that all species are within the limits observed in suspensory or climber Primate/Xenarthra species, however their body mass suggests that *P. onca*, *S. fatalis* and the subadult of *S. populator* could be climbers, while the adults of *S. populator* and *P. atrox* should be fully terrestrial. These results open interesting possibilities: *S. fatalis* could have a wide niche, hunting in trees or on the ground, independent of its ontogenetic age, while *S. populator* appears to have a clear niche separation based on their age; younger animals could hunt prey in trees, whereas adults could only take prey on the ground. The same pattern could occur with *P. atrox*; however, we did not have data to confirm this.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**TAXONOMIC SIGNIFICANCE OF LUNGFISH (SARCOPTERYGII: DIPNOI) TOOTH PLATES IN THE LOWER TRIASSIC (OLENEKIAN) BURGERSDORP FORMATION OF DRIEFONTEIN, SOUTH AFRICA**

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While dipnoan (lungfish) fossils are rare at most localities, their fossil record is known across all continents since the Devonian but is not well constrained across the Permian-Triassic boundary (PTB). The Lower Triassic (Olenekian) Driefontein locality of the Karoo Basin, South Africa, in the lowest *Cynognathus* Assemblage Zone of the Burgersdorp Fm, yields dozens of tooth plates assigned to the genus *Ptychoceratodus*, and thus is a prime site for studying lungfish recovery post-PTB. Lungfish possess a readily diagnostic dentition, and these tooth plates are typically the only part of the animal that is preserved. Taxonomic assignments of these plates are based on the number, size, and shape of the ridges and intervening furrows, albeit this is complicated by allometry and other ontogenetic/positional variation. We report three tooth plate morphotypes from Driefontein: the previously assigned *Ptychoceratodus*, a much larger *Arganodus*-like taxon, and a *Gnathorhiza*-like morphology. All three genera coexisted in the Olenekian of Russia and are also found at Olenekian localities in Poland, but *Gnathorhiza* is absent from Africa and *Arganodus* is absent from Sub-Saharan Africa. In *Ptychoceratodus*, palatal plates have five ridges and splenial plates have four. The ridges are straight, narrow, covered with denticulations, and are separated by deep furrows and wide sulci. The sulci are more sunken into the furrows on splenial plates. In comparison, three plates and some cranial material can be distinguished as *Arganodus*; two palatal plates with seven ridges and one splenial plate with six ridges. The sulci are not as wide or sunken, but the overall shape of the tooth is broader with a flatter surface. Additionally, at least five (palatal) plates resemble those of *Gnathorhiza*, having four ridges with large denticulations, but minimal sulci. The ridges radiate from the center of the plate instead of an anterior corner, with the first curving posteriorly at its base. We found that the ridges of palatal plates in the first two morphs form an inner angle ($C_1BC_P$) of 90º-100º and secondary angle ($C_2BC_P$) of 60º-70º; *Gnathorhiza*-like plates form much more obtuse inner angles (>130º). Splenial *Ptychoceratodus* plates are highly variable, hinting at even greater taxonomic diversity. The occurrence of *Arganodus* and *Gnathorhiza*-like morphs at Driefontein greatly expands their geographic range, providing more evidence for the recovery of lungfish after the Permian extinction.

**Funding Sources** We acknowledge an undergraduate research assistantship (URA) to the senior author and a Fulbright Global Scholar Award to the second author.

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Technical Session 3: Fishes & Amphibians (Wednesday, October 18, 2023, 8:00 AM)

## SYNCHROTRON-XRF AND VIBRATIONAL SPECTROSCOPY REVEAL SOFT TISSUES IN THE HORNED TETRAPOD *KERATERPETON* (PENNSYLVANIAN, JARROW, IRELAND)

Rossi, Valentina[1], O'Gogain, Aodhan[2], Unitt, Richard[1], McNamara, Maria E.[1]

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The Jarrow coal seam (Pennsylvanian; Co. Kilkenny, Ireland) has yielded diverse fossil vertebrates that are important for understanding the evolution of non-amniote tetrapods. Specimens of the horned tetrapod *Keraterpeton galvani* (Nectridea) are usually complete and (near-)fully articulated, but soft tissues are not readily apparent. This is due to the uniform black color of the specimens and surrounding coal and bituminous shale matrix. Here we resolve this issue by studying two specimens of *K. galvani* using synchrotron-X-Ray Fluorescence (XRF) imaging, computed tomography (CT), scanning electron microscopy (SEM) and Fourier transform infrared (FTIR) and Raman spectroscopy. Our results show that copper (Cu) – an element often associated with fossil melanosomes – is associated with the torso, abdomen and tail of both specimens. FTIR and Raman spectroscopic analyses reveal differences in the intensity and position of peaks associated with aromatic compounds between soft tissues and sediment samples. Statistical analyses demonstrate that the chemical composition of these regions differs significantly from that of the surrounding matrix. SEM analyses show that the Cu-rich material contains microbodies that resemble poorly preserved melanosomes. Collectively, these data suggest that the degraded remains of melanosome-rich soft tissues are preserved in *Keraterpeton*, which thus represents the oldest known fossil tetrapod preserving evidence of fossil melanin.

**Funding Sources** This project is supported by an ERC Consolidator Grant 'Palaeochem' (H2020-ERC-COG-101003293) awarded to M.M.

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Technical Session 2: Early Mammals & Carnivora (Wednesday, October 18, 2023, 8:00 AM)

## SURFACE DEFECTS/PORES/PITS AND THEIR IMPLICATIONS: A SURVEY OF CARNIVORE FRONTAL AND PARIETAL BONE SURFACES

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Vascular plexus-attributed cranial surface alterations have been noted in families of Artiodactyla and in select Perissodactyla and Carnivora. Subsequent study of Carnivora revealed previously undescribed skull surface alterations, in addition to the phenomenon observed in recent and fossil male lions. A study was therefore performed to characterize and assess the phylogenetic distribution of cranial surface alterations in carnivores.

The parietal and frontal regions of carnivore skulls were systematically examined by surface microscopy in major skeletal collections, including, but not limited to those of the Field Museum of Natural History, Indiana State Museum, Purdue University, University of Kansas Museum of Natural History, and the United States National Museum of Natural History. In addition to identification of the parietal and frontal ectocranial bone alterations previously related to vascular plexuses, two previously unreported phenomena were noted: 1. Penetrating channels with widening of the surface aperture. 2. Distinct textured surfaces, in contrast to the normal smooth parietal and frontal bone external surfaces. Additionally, extent of normal transcortical vascular channels was characterized.

Alterations previously attributed to vascular plexuses in artiodactyls were documented in *Canis simensis, Lycaon pictus, Otocyon megalotis, Panthera leo*, *P. tigris, P. pardus, Neofelis nebulosa, Acinonyx jubatus, Ursus arctos, U. maritimus*, *Enhydra lutris, Hyaena hyaena, Vulpes lagopus, Halichoerus grypus* and *Phoca barbatus*. Widened structures were noted in *U. arctos* and *U. thibetanus* and *H. hyaena*. Textured surfaces were noted in individual *C. simensis*, *O. megalotis, P. tigris,* and in *U. arctos, U. americanus* and *U. thibetansus*.

The distribution of alterations attributed to vascular plexuses was not limited to hot environments, but also found in those with arctic exposure. Countercurrent warming may be as important to them as cooling in other groups studied. The textured phenomenon was observed in isolated individuals, suggesting the possibility of a taphonomic effect. Channels with widened external apertures were generally observed among species in which vascular plexus-type alterations are also present. Study

continues to enlarge the data base to permit further exploration of environmental impact on transcortical cranial circulation and development of vascular plexuses.

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Technical Session 2: Early Mammals & Carnivora (Wednesday, October 18, 2023, 8:00 AM)

**A MESUNGULATID MAXILLA FROM THE LATE CRETACEOUS LA COLONIA FORMATION (CHUBUT PROVINCE, ARGENTINA) SHOWING EVIDENCE OF TOOTH REPLACEMENT: THE MOLAR-PREMOLAR BOUNDARY IN DRYOLESTOIDS AND STEM THERIANS.**

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[1]Anatomical Sciences and Neurobiology, University of Louisville, Louisville, Kentucky, United States, [2]Universidad de Buenos Aires, Buenos Aires, Argentina

The Late Maastrichtian La Colonia Formation has yielded a large number of mammalian remains, mostly isolated teeth. The published fauna is dominated by the large-sized mesungulatid *Coloniatherium* and the smaller *Reigitherium*. Both are primarily known by a combination of isolated teeth and jaw fragments. None of these specimens show direct evidence of tooth replacement, but tooth series have been reconstructed based in part on the more complete dentitions of other meridiolestids. Therefore, the identification of premolars and molars has rested largely on morphology. We present here a partial right maxilla of a mesungulatid, regarded as *Mesungulatum* sp., which shows deciduous dentition and replacement.

In occlusal view the maxilla shows two molariform elements, the posterior root of a mesial tooth, and a partial mesial alveolus. Direct observation and CT study reveals two additional teeth enclosed in the maxilla. One lies under the mesial tooth; the second is under the first fully preserved molariform. No tooth is developing under the second erupted molariform. We identify the erupted teeth as the last two deciduous premolars and the first molar; the teeth still in the maxilla are the last two permanent premolars. Both are in an advanced state of calcification but lack roots and are not yet erupting. The last premolar is fully molarized, while the penultimate corresponds to the simpler morphology identified as that of a penultimate premolar in other meridiolestids. There is enough preserved of the alveolus of the M2 to show that this tooth was fully erupted, with the impression of the mesial root extending all the way to through the maxilla.

This specimen corroborates the identification of three molars in meridiolestids as a whole and the presence of a fully molarized last permanent premolar preceded by a complex (yet not fully molariform) penultimate premolar. This pattern of dental homologies and tooth formula, originally advanced based on observation of wear and root morphology, has been challenged based on the pattern of dental replacement in Dryolestidae, where the last premolar is a simpler tooth. Meridiolestids and dryolestids therefore strongly differ in this regard. Root morphology is a reliable proxy to recognize premolars and molars in meridiolestids. Molarization of the last premolar is found in *Cronopio dentiacutus* and thus appears ancestral to Meridiolestida; it may also apply to amphilestids, zhangheotheriids, and other trechnotheres.

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Romer Prize Session (Thursday, October 19, 2023, 8:00 AM)

**SKULL FUNCTION IN THEROPOD DINOSAURS: IMPLICATIONS FOR BODY SIZE AND MACROEVOLUTION**

Rowe, Andre J.

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Theropods are notable for including the largest terrestrial bipeds ever. Large body size evolved in several phylogenetically disparate theropod clades, including the tyrannosauroids, allosauroids, and megalosauroids, and at different times from the Middle Jurassic to Late Cretaceous. Body size increases impose structural and physiological constraints on function; while the impact of large body size on theropod dinosaur locomotion has been assessed before, its effects on feeding function remains largely unknown, in part due to difficulties in capturing 3D digital anatomy of large skulls. Here, we investigate the impact of increasing body size on skull feeding function. We used computed tomography scanning and surface scanning to create 3D digital models of 21 theropod dinosaur skulls across several clades including Tyrannosauroidea, Megalosauroidea, Allosauroidea, and Abelisauroidea.

3D finite element analysis was used to study stress and strain occurrences in the skull during simulated feeding loads, with applied force taken from estimated muscle masses. When skulls were analyzed at actual size and estimated muscle force, larger tyrannosauroid taxa experienced higher skull stresses than smaller taxa, whereas this body size-related trend in increased stress is not observed in non-tyrannosauroids. In a second dataset, muscle forces were scaled to maintain a consistent ratio of muscle force: skull surface area which accounted for skull size differences between taxa. At equivalent size, smaller theropod skulls experienced higher stresses, particularly abelisauroids and the early saurischian *Herrerasaurus*. These results indicate that large non-tyrannosauroid theropods had relatively more strongly constructed skulls and experienced lower stresses than smaller taxa at actual size. Large tyrannosauroids possessed strongly constructed skulls but also experienced higher stresses than smaller taxa at actual size and were thus accommodating more force per unit area. We argue this represents a trade-off where the expanded tyrannosauroid posterior skull and increased adductor muscle mass generates high bite forces, which results in the need to accommodate greater stresses in the skull during feeding. Thus, despite their size, large tyrannosauroids may have sacrificed skull strength for a greater bite, a trend which appears to be absent in other large-bodied theropod clades.

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**NEUTRON TOMOGRAPHY PROVIDES NEW INFORMATION ON THE FOOT MORPHOLOGY OF THE EARLY PERMIAN VARANOPID *MESENOSAURUS EFREMOVI***

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The focus of this study is the pelvic girdle and hindlimb of the varanopid *Mesenosaurus efremovi*. Varanopids are a group of relatively uncommon synapsids with a wide geographic distribution throughout North America, Europe, Russia, and South Africa. While the hindlimb morphology of numerous varanopids including *Mesenosaurus romeri* has been described previously, *Mesenosaurus* has not been examined in great detail and the postcrania of *Mesenosaurus efremovi* was not previously described. A well-preserved pes of this varanopid, along with a partial tibia and fibula, was well-suited for neutron tomography due to the close association of all elements. Three-dimensional modeling of this specimen has resulted in the opportunity to closely examine and digitally rearticulate the pes of *Mesenosaurus efremovi*. As with *Mesenosaurus romeri*, the metatarsals are elongate and gracile, and as in other varanopids the fourth metatarsal is unusually long. However, the fourth tarsal is disproportionately large, with significant sites of contact with the astragalus posteriorly and the calcaneum laterally. The contact between the fourth tarsal and the astragalus results in a shallow groove on the distal surface of the astragalus. Dorsally, a transverse flange extends along the astragalus into the perforating foramen, creating a shallow pocket for articulation with the tibia. Unlike most other varanopids, the calcaneum is not rounded laterally and instead possesses a well-developed lateral tuberosity. This feature is indicative of the ability to flex the foot during a step cycle. These features provide significant data into the morphology and potentially the locomotion of this early synapsid.

**Funding Sources** This research was supported by an NSERC Discovery Grant and funding from Jilin University.

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Technical Session 16: Theropods - I (Saturday, October 21, 2023, 8:00 AM)

**MULTIPLE UNRECOGNIZED SPECIES OF *VELOCIRAPTOR* IN THE *VELOCIRAPTOR MONGOLIENSIS* SPECIES COMPLEX**

Ruebenstahl, Alexander A.[1], Powers, Mark J.[2], Napoli, James G.[3], Chinzorig, Tsogtbaatar[3], Turner, Alan H.[4], Bhullar, Bhart-Anjan S.[1], Norell, Mark A.[5]

[1]Earth and Planetary Sciences, Yale University, New Haven, Connecticut, United States, [2]University of Alberta, Edmonton, Alberta, Canada, [3]North Carolina Museum of Natural Sciences, Raleigh, North Carolina, United States, [4]Stony Brook University, Stony Brook, New York, United States, [5]American Museum of Natural History, New York City, New York, United States

*Velociraptor mongoliensis* Osborn 1924, has played a key role in our understanding of both dromaeosaurid anatomy and the origin of birds. Over a dozen specimens from Mongolia have been referred to *V. mongoliensis*. However, several similar dromaeosaurid species (e.g., *Tsaagan mangas*) are also known from comparable Central Asian sediments, making referral of these specimens to *V. mongoliensis* uncertain. In the absence of a recent apomorphy-based diagnosis of *V. mongoliensis* benefitting from CT datasets and comparison with newly described dromaeosaurids, it is possible that the *V. mongoliensis* hypodigm includes multiple species. This issue is not unprecedented, as *T. mangas* was provisionally referred to *V. mongoliensis* upon discovery.

Using 8 novel microCT scans of skulls as well as firsthand observations and surface scans of specimens referred to *V. mongoliensis*, we employed new Bayesian methods (BiDOV) to test their referral to *V. mongoliensis*. Character data from modern species was used to determine the probability that two or more fossil specimens belong to the same biological species. Degrees of ontogenetic and individual variability in modern species characters were used to refine BiDOV and report our results.

We find strong evidence for the presence of 3 new taxa among specimens referred to *V. mongoliensis*. IGM 100/982, often cited as an exemplar *V. mongoliensis*, is recognized as a new, long snouted species of *Velociraptor*. IGM 100/976, a specimen with a bite wound in the skull roof, possesses divergent braincase from other specimens of *Velociraptor*. This has implications for interspecific predation in velociraptorines, and the understanding of *Velociraptor* paleoneurology, as this specimen is the primary reference for the *Velociraptor* braincase. Finally, IGM 100/3503, known for its ulnar quill knobs, is likely a new species. The absence of quill knobs in other *Velociraptor* specimens cannot be interpreted as intraspecific variation. BiDOV also indicates that the nearly complete specimens IGM 100/54 and IGM 100/25, among others, can be assigned confidently to *V. mongoliensis*. The new taxa represented by IGM 100/982 and IGM 100/976 are both known from separate localities (Bayn Dzak and Tugrigeen Shireh), but both are coeval with *V. mongoliensis*. These results therefore add to a growing picture of diverse dromaeosaurid faunas in the Late Cretaceous, with multiple similarly sized and closely related dromaeosaurids coexisting in the same environment.

**Funding Sources** Alexander Ruebenstahl was funded by the Yale University Graduate student fellowship, the Yale Institute for Biospheric Studies and the career grant of Bhart Anjan Bhullar

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Technical Session 20: Marine Mammals & Bats (Saturday, October 21, 2023, 1:45 PM)

**AN ARCHAIC SOUTHERN TRUE SEAL (SUBFAMILY MONACHINAE) FROM THE LATE NEOGENE OF NEW ZEALAND REVEALS THE ORIGIN OF HIGH FREQUENCY HEARING IN PHOCIDAE**

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Pinnipeds are the only mammals able to hear amphibiously, with their underwater hearing ability mostly comparable to their airborne hearing. However, Phocidae (true seals) typically hear higher frequencies underwater than Otarioidea (fur seals, sea lions, walrus), with some lobodontins (Antarctic true seals) capable of ultrasonic vocalizations. This bioacoustic partitioning between the two groups may reflect differing ecologies. However, a lack of research on the acoustic morphology of extant and fossil pinnipeds, and sufficiently archaic monachine fossils preserving basicrania, has limited our insights into the origins of high frequency hearing and vocalizations.

To investigate the origins of high frequency hearing in phocids, we report a new fossil monachine (southern true seal) and analyze it with extant and extinct Phocidae. The new monachine is a basicranium from the Greta Siltstone (13-3 Ma) of Motunau, New Zealand. The Motunau monachine possesses a hitherto undocumented suite of auditory morphology, more archaic than that of extant lobodontins and fossil monachines from Peru and South Africa. A fossilized birth-death Bayesian phylogenetic analysis of Phocidae (all living taxa plus 18 extinct taxa, employing tip and node dating) resolved the Motunau specimen as sister to all other fossil and extant Monachinae (except *Monotherium*? *wymani*).

To explore the evolution of high frequency hearing in Phocidae, we micro-CT scanned the Motunau specimen along with seven fossil and all species of extant phocids, and representatives of the otarioid outgroup. We then used 3D GMM, linear morphometrics, and phylogenetic comparative methods on the middle and inner ears of the resulting 3D models to test for correlation with hearing frequency. Principal component analysis of the auditory morphology revealed that phocid ears differed substantially from otarioids and identified distinct morphotypes related to high frequency hearing. Phylogenetic comparative analysis of these ear morphotypes revealed an early origin for high frequency hearing in Monachinae. This suggests that high frequency hearing, and possibly vocal reproductive displays, have been present in the sensory ecology and behavior of phocids since early in their history.

**Funding Sources** Project supported by: UKRI Fellowship

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

## ASSESSING MORPHOLOGICAL CHANGE IN THE UPPER DENTITION OF THE *TETONIUS – PSEUDOTETONIUS* (MAMMALIA, PRIMATES) LINEAGE FROM THE WILLWOOD FORMATION (EARLY EOCENE) IN THE BIGHORN BASIN OF WYOMING, USA

Rust, Kathleen L., Beard, K. Christopher

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The Willwood Formation (early Eocene) in the Bighorn Basin of Wyoming offers a virtually continuous fossil record documenting evolutionary changes at high resolution. Previous studies found that the *Tetonius – Pseudotetonius* lineage of omomyids exhibits a pattern of gradual morphological change in lower dentition spanning 1.5 million years, resulting in progressive compaction of the anterior dentition and loss of tooth loci in later taxa. At the time, insufficient samples of fossil maxillae prevented formal analysis of similar changes in the upper dentition. Additional fossil maxillae from the *Tetonius – Pseudotetonius* lineage have now been recovered and are studied here.

Here, we present results of morphological analyses designed to test whether coordinated changes in the upper dentition match modifications previously documented in the lower dentition. While our analyses document morphological changes in the upper dentition through time, these transformations do not evolve in tandem with those documented in the lower dentition. While dentaries of *Tetonius* from meter levels 200-290 demonstrate the evolutionary loss of $P_2$, a partial *Tetonius* fossil maxilla from meter level 212 maintains $P^2$. Additionally, while the crown size and roots of $P_3$ are mesiodistally reduced and fused relative to $P_4$ at meter levels 278-348, the crown size and roots of $P^3$ at lower meter levels of this interval are neither mesiodistally compressed nor fused. Rather, the crown size is only slightly mesiodistally reduced, and roots remain widely splayed. Interestingly, the crown height of $P^4$ relative to $P^3$ is significantly larger at meter level 348, suggesting that changes in $P^4$ crown height mirror changes occurring in crown height of $P_4$.

Our findings suggest that the changes occurring in the upper and lower dentition of this lineage conform to a pattern of mosaic evolution. While understanding the selective forces driving mosaic evolution in this lineage is challenging, functional explanations are plausible. The evolutionary retention of $P^2$ in higher meter levels may indicate retention of a vestigial structure while selective pressures acted on increasing the crown height of the upper and lower fourth premolars to perform or enhance specific masticatory functions.

**Funding Sources** This research was supported by grants from the Association of Earth Science Clubs of Greater Kansas City, the University of Kansas, and the David B. Jones Foundation.

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Virtual Posters

## UNIQUE INTERNAL ANATOMY OF CERVICAL VERTEBRAE DISCOVERED IN TRIASSIC ARCHOSAUROMORPHS FROM CENTRAL EUROPE

Rytel, Adam A.[1], Surmik, Dawid[2], Szczygielski, Tomasz[1], Scheyer, Torsten[3]

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Extreme neck elongation was one of the key adaptive features partaking in achieving the evolutionary success in many distantly related vertebrate groups, both terrestrial and aquatic. While in some taxa it developed mostly through somitogenesis (e.g., sauropterygians), cervical vertebrae elongation contributed in a major way to the relative neck length increase in other animals (e.g., dinosaurs, pterosaurs, turtles, giraffids). An extreme example of the latter condition can be observed in the Middle Triassic family Tanystropheidae, with *Tanystropheus* exhibiting cervicals more than ten times longer than tall. Despite the long history of research, and numerous complete skeletons of tanystropheids found in the Monte San Giorgio area, the internal anatomy and biomechanics of their unusual vertebrae remain poorly known due to mostly two-dimensional preservation of the articulated specimens. The newly excavated three-dimensionally preserved material from the Middle Triassic sediments of Upper Silesia (Poland) allowed us to overcome this constraint. In this study, we used computed microtomography and thin section sampling of the cervical vertebrae of *Tanystropheus* sp. and "*Tanystropheus"* (*Protanystropheus*) *antiquus* to reconstruct their internal anatomy and evaluate its biomechanical implications.

In all of the sampled specimens, a large internal cavity is present in the vertebral centrum. In *Tanystropheus* sp. it is not separated from the neural canal and encompasses most of the volume of the vertebra. In "*T.*" *antiquus*, it is relatively smaller, with a very thin, noncontinuous, bone layer forming the ventral boundary of the neural canal. Semi-symmetric, slanted trabeculae connect the inner walls of the centra in some of the samples. As no clear correlates of pneumaticity were observed so far, the internal cavities were probably filled with soft tissue, most likely bone marrow. The extent of the cavity in the vertebrae of *Tanystropheus* sp. would seem to contradict, but not decisively, the aquatic lifestyle proposed for this animal.

Our study supports the uniqueness of the anatomical characteristics of the analyzed cervicals, not only superficially, but also internally. It is, perhaps, possible that the large soft-tissue-filled cavities were present in the common ancestor of archosauromorphs and were later invaded by the diverticula of the air-sacs, evolving into the highly pneumatic bones of some archosaurs.

**Funding Sources** This study was supported by the Polish National Science Centre grants 2017/27/B/NZ8/01543, 2019/32/C/NZ4/00150, 2019/35/N/NZ8/03806 and 2020/39/O/NZ8/02301.

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**SEXING DINOSAURS: POSSIBLE DETECTION OF TRACE SEX HORMONES IN FOSSILS AS OLD AS THE JURASSIC AND THE THERMAL STABILITY OF ESTROGEN**

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Sex is an important variable in morphological, ecological, and behavioral research, but identifying a fossil's sex without close modern analogs, complete material, or pronounced dimorphism is highly uncertain. Prior research detected preserved metazoan steroid cholesterol and its diagenetic products back to the Ediacaran. Steroidal sex hormones are biosynthesized from cholesterol. Cholesterol diagenesis predicts even fully fossilized sterane products of hormones would differ between feminizing estrogens, masculinizing androgens, and from other steroids (cholesterols, progestogens, corticosteroids) based on their carbon skeletons. Low aqueous solubility of steroids may limit loss into the environment, but their low mass fraction in bone is the key challenge.

We empirically test sex hormone fossilization potential with thermal maturation experiments and direct analyses of fossils. Hormone standards (Sigma-Aldrich) and modern bird bones underwent sealed-capsule and sediment-encased temperature-pressure maturation experiments. Untreated and matured standards and bone (with surrounding clay as applicable) were analyzed for lipids alongside nine fossil non-avian dinosaur, crocodilian, ichthyosaur, mammalian, and fish bones (Oligocene–Jurassic age range). Samples were abraded to remove surface contamination, powdered in a clean lab, Soxhlet extracted for lipids, and separated by column chromatography to yield an alcohol-dominated fraction that was TMS-derivatized and analyzed by gas chromatography-mass spectrometry.

Estradiol is little altered by maturation up to 245 °C, 250 bar, 24 hr, consistent with predicted stability conferred by its aromatic ring. Key ions of estradiol are more easily observed above instrument baseline in sediment-maturated bird bone than in the surrounding clay. Trace estradiol was possibly detected in about half the fossils (Oligocene Chadron Fm. mammal, Late K Hell Creek Fm. *Triceratops*, Early K Wessex Fm. dinosaur, Early J Blue Lias Fm. ichthyosaur) alongside cholesterol, suggesting conditions conducive to steroid preservation.

Our results suggest sex hormones could preserve deep into the fossil record. Their potential to refine sex identification methods would improve the accuracy of sexual dimorphism estimates and the study of sexual selection on macroevolution. Future work will increase sample size, add further controls, lower the detection limit, and examine diagenetic alterations to the likely less stable testosterone.

**Funding Sources** This work was supported by the Palaeontological Association's research grant PA-RG202202.

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**CAN YOU EAT WELL IN FLATLAND? A CASE STUDY ON WHEN TWO-DIMENSIONAL GEOMETRIC MORPHOMETRIC ANALYSIS IS SUFFICIENT FOR THE FUNCTIONAL MORPHOLOGICAL ANALYSIS AND EVOLUTION OF "FLAT" BIOLOGICAL SHAPES**

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Using three-dimensional coordinates in geometric morphometric analysis is generally a more realistic analysis of the differences in shape between homologous biological shapes in organisms. These analyses are often used to quantify the variation of shape and to see if this variation is related to aspects of function (i.e., force generation, stress distribution) and can be analyzed regarding a clade's evolution. Before this however, an analysis using two-dimensional coordinates, often from a view of most significance to capture the greatest variation in the shape of a particular organism, is often done as a preliminary study to assess a simpler analysis of variation in shape and to refine methods for analyses using three-dimensions. This is often done due to the ease in both landmarking and acquiring data to use for shape analysis in two-dimensions versus three dimensions (photographs versus three-dimensional models or the specimens themselves). However, is there a point in which two-dimensional coordinates, in themselves, are enough for a comprehensive analysis of shape and where the addition of the z-axis of shape given in three-dimensional analysis does not add as much to the overall variation? Such opinions could be argued with organismal features and shapes such as mandibles, scapulae, or shells that have been described as such in the past because they are relatively "flat."

This study analyzes the amount of variance captured and the amount of functional variance explained by shape in the mandible of mammalian carnivores from both two-dimensional and three-dimensional coordinate-based geometric morphometric analysis to infer if the addition of three-dimensionality significantly improves analysis of the relationship between form and function of the carnivoramorphan jaw. Results were then further scrutinized on whether differences in results are due to either: a) the additional of three-dimensionality or b) phylogenetic sampling (in which differences are contributed from how related the sampled taxa in the study are with Carnivoramorpha versus ecologically and morphologically similar taxa in Theria). An additional study is whether semilandmarks on a curve effect of how taxa are distributed in morphospace and how they tend to group based on the greatest difference in variation.

**Funding Sources** Norman R. King Graduate Field Research Fellowship, AmeriCorp Education Reward

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Paleontological Management Poster Session (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**A PALEONTOLOGICAL RESOURCE INVENTORY OF THEODORE ROOSEVELT**

**NATIONAL PARK REVEALS POTENTIAL FOR FUTURE VERTEBRATE PALEONTOLOGICAL RESEARCH AND MANAGEMENT**

Salcido, Charles J.[1], Wilson, Patrick J.[2], Tweet, Justin[3], McCann, Blake[4], Boyd, Clint A.[5], Santucci, Vincent[3]

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An increasing awareness of paleontological resources in national parks has been followed by an increase in National Park Service (NPS) paleontological inventories to better manage such resources. Theodore Roosevelt National Park (THRO), established in 1947 and located in western North Dakota, preserves portions of badlands containing the Bullion Creek Formation and Sentinel Butte Formation representing six million years of deposition during the Paleocene. Paleontological studies of these formations have been primarily outside of park boundaries and have documented various plants, invertebrate, and vertebrate taxa. Previous surveys of the park showed that these units in the park’s boundaries have been very fossiliferous with petrified wood being a known feature and a 1994–1996 survey that recorded 400 localities. This highlights THRO’s importance as an area with great potential for scientifically significant material as it is one of the few park units in the NPS system that contains Paleocene fossil-bearing geological units, and only one of two with substantial Paleocene terrestrial records.

The author conducted a survey of THRO in 2020–2021 to create a paleontological resource inventory to determine the scope, significance, distribution, and management issues associated with fossil resources in the park. The survey included 14 weeks of fieldwork which recorded 158 localities over 9.1 km$^2$ of the park in both the North and South Units. Over 75% of the localities were from the Sentinel Butte Formation. This survey has shown that the park's geologic units are as fossiliferous as they were in past surveys and has yielded previously unidentified taxa within the park's boundaries. These included two mammalian taxa and one avian ichnotaxon. Additionally, there were high-yield sites including remains of crocodilians, champsosaurs, and turtles along with microsite localities. Management plans include encouraging monitoring and awareness with park staff, assessing areas for ground-disturbing maintenance, the formation of a repository agreement with the North Dakota Heritage Museum and State Museum, and developing a long-range interpretive plan. Based on this, future paleontological research of the fossil resources in THRO will be of great interest and well-managed.

**Funding Sources** AmeriCorps, Conservation Legacy, National Parks Service

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Technical Session 14: Crocodylomorphs & Turtles (Friday, October 20, 2023, 1:45 PM)

**A PEIROSAURID CROCODYLIFORM FROM THE UPPER CRETACEOUS (CENOMANIAN) BAHARIYA FORMATION OF THE BAHARIYA OASIS, WESTERN DESERT, EGYPT**

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The Upper Cretaceous (Cenomanian) Bahariya Formation of the Bahariya Oasis in the Egyptian Western Desert has yielded a diverse assemblage of non-avian dinosaurs. Crocodyliforms, however, are less diverse, being represented to date by only three valid taxa: the notosuchian *Libycosuchus brevirostris*, the stomatosuchid neosuchian *Stomatosuchus inermis*, and the aegyptosuchid eusuchian *Aegyptosuchus peyeri.* Here we report Mansoura University Vertebrate Paleontology Center (MUVP) specimen 523, an isolated, partial right dentary of a medium- to large-sized peirosaurid crocodyliform from the Bahariya Formation. MUVP 523 exhibits several synapomorphies of

Peirosauridae, a Gondwanan Cretaceous mesoeucrocodylian clade that has not previously been reported from northeastern Africa. These synapomorphies include the wide divergence angle (48°) of the mandibular rami, the sinusoidal dorsal margin of the dentary comprising two distinct waves, and the mediolaterally compressed, vertical ventrolateral surface anterior to the mandibular fenestra. Additionally, the anteriormost alveoli are strongly procumbent and the dentary is concave lateral to the 6th/7th and 8th/9th alveoli for the reception of two enlarged maxillary teeth. The 1st, 4th, and 11th dentary teeth are enlarged, and the dentary crowns are conical and triangular in labial view with a gently curved apex. Phylogenetic analysis recovers the Bahariya form within Peirosauridae, in a clade that also includes *Miadanasuchus oblita* from the Maastrichtian of Madagascar and *Barrosasuchus neuquenianus* from the Santonian of Argentina. This clade is supported by unambiguous synapomorphies including a dentary symphysis that is U-shaped in ventral view and smoothly curving anteriorly, with an elongate, anteroposteriorly shallow concavity lateral to 5th–10th teeth on the lateral surface of dentary to receive an enlarged premaxillary tooth. Moreover, the three taxa lack a 'peg' at the posterior edge of the mandibular symphysis. MUVP 523 therefore represents the first unquestionable peirosaurid from Egypt and northeastern Africa more generally. The new specimen augments the crocodyliform assemblage of the Bahariya Formation and, when considered in tandem with taxa from northwestern Africa, demonstrates the wide geographic distribution of Peirosauridae across northern Africa during the middle Cretaceous.

**Funding Sources** Mansoura University, American University in Cairo, Science and Technology Development Fund (STDF).

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Technical Session 10: Euarchontoglires & Xenarthra (Friday, October 20, 2023, 8:00 AM)

## ANATOMY AND PALEOECOLOGY OF THE WORLD'S LARGEST SQUIRREL (SCIURIDAE), THE GIANT MARMOT *PAENEMARMOTA BARBOURI*

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The giant marmot, *Paenemarmota barbouri*, is known from fragmentary material recovered from Pliocene-aged sites in western and central North America and represents the largest known member of the squirrel family (Sciuridae). Here, we report a remarkably complete skeleton of *P. barbouri* from Hagerman Fossil Beds National Monument in Idaho, which dates between 4.18 and 3.79 Ma based on radioisotopic dates and magnetostratigraphy. The skeleton (HAFO 4871) includes a nearly complete cranium and mandible, a partial hyoid, the pectoral girdle, pelvis, nearly complete forelimbs and hindlimbs, and much of the axial skeleton. The completeness of this material offers a unique opportunity to assess variation in ecomorphological inferences from multiple proxies. Thus, we estimate body mass based on a wide range of measurements. We find the average estimate based on cranial measurements to be 16.1 kg whereas the average based on postcranial data is 12.5 kg. These body masses are quite similar to the range of published estimates. We also use a sample of 77 modern and 24 fossil sciurids, along with a broader sample of rodent species with varied ecology, for several multiproxy ecomorphological analyses of the craniodental structure and postcranial skeleton. We infer *Paenemarmota* to have had a generalist herbivore diet, but with greater specialization for herbivory (more robust incisors and relatively larger grinding area of cheek teeth) than extant marmotines like *Marmota* and *Cynomys*. Our analyses of locomotion converge on a semi-fossorial locomotion for *Paenemarmota*. However, it had relatively larger humeral epicondyles and olecranon process of the ulna than living marmots and ground squirrels, suggesting greater specialization for scratch-digging. These cranial and postcranial features suggest that *P. barbouri* foraged on surface plants and excavated burrows for refuge, like its extant relatives, but had accentuated morphological adaptations, likely as a consequence of its greater body size. Being several times larger than the largest extant marmots, but having similar dietary and locomotor ecology, raises questions about the interactions of *Paenemarmota* with predators, as it may have been a relatively easy prey for large canids and felids and vulnerable to badgers and large birds of prey.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**NEW INFORMATION ON APPENDICULAR ELEMENTS AND ONTOGENTIC LIFE STAGES OF BASAL CAPTORHINID REPTILES: ADDITIONAL JUVENILE POSTCRANIAL SKELETAL REMAINS OF THE EARLY PERMIAN EUREPTILIAN REPTILE *LABIDOSAURUS***

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Elements of the early Permian captorhinid reptile *Labidosaurus* (Amniota, Reptilia, Eureptilia, Captorhinidae) preserve both juvenile and adult components of the axial and appendicular skeletons. Materials collected by Everett Olson from the early Permian sediments of the Clear Fork Group (undivided) in Baylor County of north-central Texas include mature and juvenile postcranial components of *Labidosaurus.* Olson originally identified this locality as "Arroyo Formation" designating it as the "*Labidosaurus* pocket" as materials there are dominated exclusively by that genus. Specimens from this locality have been the basis of numerous studies of mature, adult structure of *Labidosaurus* based primarily on two nearly complete specimens. A re-examination of the entirety of Olson's collections from this locality has previously revealed post-cranial vertebrae, femora, and tibiae from at least three life stages including adults, subadults, and juveniles. Analysis of material from the *Labidosaurus* pocket now allows identification of elements assignable to at least one other adult individual. Further, juvenile humeri are now also reported in addition to the axial skeleton and pelvic limb elements previously described. Two proximal right and one distal left juvenile humeral fragment may be recognized. All have unfinished articular surfaces. The proximal elements are approximately 70 to 80 percent that of the adult humeri recovered from the same locality. The most dramatic proportional difference between adult and juvenile humeri is the much greater distance between proximal articular surface and deltoid tuberosity in adults as compared to juveniles. The capitulum is not evident, presumably only present as cartilage in the left distal specimen. With at least three adults and two juveniles identified, Olson's *Labidosaurus* pocket preserves at least five individuals representing as many as three different ontogenetic life phases. This may confirm the preservation of multiple life-stages of a single genus at the locality. Further, if the conditions of preservation might reflect life associations patterns, it could be the earliest evidence of social interactions between differing ontogenetic stages in the reptilian fossil record.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**ALLOMETRIC TRENDS IN LIMB REDUCTION OF THE PLEISTOCENE DWARF MOUNTAIN GOAT *OREAMNOS HARRINGTONI* (ARTIODACTYLA: BOVIDAE)**

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Phyletic dwarfing in the fossil record is quite common, and numerous studies document allometric changes in limbs after dwarfing. Some instances of dwarfing (especially in rhinos, hippos, deer, goats, camels, and some proboscideans) show allometric changes to more robust limbs in dwarfs, while others (most proboscideans, pronghorns, and some others) show isometric size reduction of limbs. We measured the major limb elements (humerus, femur, tibia, metacarpal, metatarsal) of the Pleistocene dwarf mountain goat, *Oreamnos harringtoni*, and compared their mean values to the living species *O. americanus* to determine the interspecific slope of dwarfing. *O. harringtoni* decreased by about 18-28% in size compared to the living mountain goat, but almost all the dwarfing slopes of the major bones (humerus, metacarpal, metatarsal) were isometric, with a slope very close to 1.0. Only the femur and tibia showed slopes that are more robust than expected, although probably not significantly so. The dwarfed mountain goats apparently had slightly more robust and stumpy hind limbs compared to the living species, possibly as an adaptation to "low-gear locomotion" on steep slopes (as is seen in some other extinct organisms, such as Pleistocene deer and goats in the Mediterranean islands, and the goatlike camel from Pliocene near Death Valley).

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Paleontological Management Poster Session (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**U.S. NATIONAL PARK SERVICE PALEONTOLOGICAL RESOURCE INVENTORY AND MONITORING SUPPORTS STEWARDSHIP, SCIENCE AND DISCOVERY OF NON-RENEWABLE FOSSIL IN PARKS**

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Accurate data is essential for the management and stewardship of non-renewable paleontological resources on federal lands. During the 1990s a National Park Service (NPS) initiative known as the Natural Resource Challenge (NRC) resulted in Congressional funding to establish an Inventory and Monitoring (I&M) Program for natural resources. The fundamental questions raised in the NRC, "How do we manage, protect, and make decisions involving NPS natural resources without good baseline resource data?" The mandate for I&M of NPS natural resources was addressed in Section 204 of the 1998 NPS Omnibus Management Act (Public Law 105-391). In 1999 the Secretary of Interior received a Congressional request for information regarding the management of paleontological resources on federal lands. A *Report to Congress on Fossils on Federal & Indian Lands* (RTC) was presented by the Department of Interior in 2000, incorporating information from federal agencies, the scientific community, and the public. Principle 5 in the RTC titled *Effective Stewardship Requires Accurate Information* states, "Inventories and monitoring of fossils on federal lands are critical for sound fossil management. Thorough inventory data enables informed decision making and enhances interagency collaboration." This information contained in the RTC was consistent with the principles of the NRC and the need for I&M of natural resources. This information was carried over into Section 6302 of the Paleontological Resource Preservation Act (2009) which states, "The Secretary shall develop appropriate plans for inventory, monitoring, and the scientific and educational use of paleontological resources." I&M of non-renewable paleontological resources is a core function and primary responsibility of the NPS Paleontology Program. The NPS defines paleontological resource inventory as the compilation of baseline data to determine the scope, significance, distribution (both temporally and geospatially), and the management issues associated with fossils. Paleontological resource monitoring is defined by the NPS to be the assessment of the stability and condition of in situ fossils to understand the natural and anthropogenic factors which contribute to their loss or deterioration. Through paleontological resource I&M the NPS has been able to apply scientific principles and resource management strategies in the stewardship of non-renewable fossils, resulting in many important new fossil discoveries in national parks.

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Preparators' Poster Session (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**MOLDMAKING AROUND ARMATURES ON A TILTED PEDESTAL: A CASE STUDY OF LARGE-SCALE FOSSIL WHALE MANDIBLES AND BALEEN IMPRESSIONS**

Sato, Tetsuya

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Moldmaking processes vary for each specimen due to differences in morphology, preservation, and size. Gamagori Natural History Museum, located on the coastal region of Japan, is home to the holotype of *Incakujira anillodefuego*, a Miocene baleen whale, despite the risk of natural hazards such as earthquakes and tsunamis. To mitigate potential damage or loss of the specimen, a high-quality cast was produced and relocated to an earthquake-proof building at the National Museum of Nature and Science in Tsukuba, Japan. This project encountered several key challenges including the molding of 2.4-meter-long mandibles and baleen impressions embedded in a pedestal with metal armatures; ensuring that the mold and mother mold were lightweight enough to be handled on the pedestal tilted at an angle of 24 degrees; and producing high-fidelity casts that accurately represent the original type specimen. To address these challenges, a solution was devised that involved creating a seamless one-part thin-walled silicone mold and a complex eight-part polyester mother mold. This approach facilitated demolding, reduced the weight of the mold, and enhanced the quality of the casts.

A five-layer method was employed using RTV silicone rubber *Shin-Etsu KE-12* (Shore A 40) with fumed silica *Aerosil* as a bulking agent and medical gauzes as reinforcement. The silicone was applied to cover the entire mandible and baleen impressions, except for the inside of the armatures. The mother mold consisted of the polyester resin *Polyhope*

*AP150* with a catalyst *Permek N*, talc, fumed silica, fiberglass cloth, and chopped strand mat. Each of the eight pieces was held together with bolts, washers, and wing nuts, eliminating the need for metal or wooden frame supports. As a result, a 20-kg silicone mold and a 20-kg mother mold were created and successfully removed from the specimen without causing damage. Two casts were produced from this mold, although the silicone rubber experienced minor tearing during demolding and casting. To prevent such tears, it may be necessary to select silicone rubber with a lower hardness scale or apply the phantom shim technique.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**A MORPHOMETRIC ASSESSMENT OF CRANIAL ONTOGENETIC AND EVOLUTIONARY TRENDS IN *TRICERATOPS* FROM THE HELL CREEK FORMATION, MONTANA**

Scannella, John[1], Purens, Kristopher[2], Horner, John R.[3]

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Intensive collecting in the uppermost Cretaceous Hell Creek Formation (HCF) of Montana and surrounding regions has produced a large (n>100) sample of the ceratopsid dinosaur *Triceratops* with contextual stratigraphic data. The two recognized species, *T. horridus* and *T. prorsus*, are stratigraphically separated within the HCF with *T. prorsus* restricted to the upper unit and *T. horridus* found lower in the formation. Studies of *Triceratops* growth indicate dramatic cranial ontogenetic changes including reorientation of postorbital horn cores and expansion of the parietal-squamosal frill. This transformation is hypothesized to result in the expanded frill morphology that diagnoses the coeval ceratopsid *Torosaurus latus*; this proposed synonymy remains a subject of research and debate. Linear and geometric morphometric (GM) approaches were applied to the HCF dataset to further test these ontogenetic and evolutionary hypotheses. GM analyses were conducted on complete skulls as well as individual cranial elements. Historically collected specimens, including the holotypes of *T. horridus*, *T. prorsus*, and *To. latus,* were included to further assess taxonomic hypotheses. Standard Major Axis regressions indicate positive allometry in the epinasal, nasal process of the premaxilla, and parietal. Statistical support is found for stratigraphic trends in the epinasal, nasal process of the premaxilla, and squamosal. Removal of landmarks for the horns and frill increase the p-value in a permutation Multivariate Analysis of Variance (from .056 to .5 in the linear dataset and .142 to .717 in the GM dataset) consistent with these potentially ornamental structures being the primary features to change stratigraphically. Principal Components Analysis of cranial bones highlight a combination of *T. horridus* and *T. prorsus* morphologies in specimens from the upper middle unit of the HCF, consistent with the evolutionary transformation of a lineage over time. *Torosaurus* are more common in the lower HCF and plot close to or overlap *T. horridus*, consistent with *To. latus* representing the mature form of *T. horridus* and suggesting that as *Triceratops* evolved it retained immature frill morphology longer in ontogeny. Alternatively, *Triceratops* and *Torosaurus* may have diverged early in or prior to deposition of the HCF with the *Triceratops* lineage culminating in *T. prorsus* in the upper unit of the formation.

**Funding Sources** Funding in part by Theodore Roosevelt Memorial Fund, AMNH; Welles Fund, UCMP; Jurassic Foundation; Evolving Earth; Intellectual Ventures, Smithsonian Institution

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**PATHOLOGICAL CHEVRONS IN THE TAILS OF THREE SPECIMENS OF *PLATEOSAURUS TROSSINGENSIS***

Schaeffer, Joep[1], Mujal, Eudald[1], Witzmann, Florian[2], Ferreira, Gabriel[3], Schoch, Rainer R.[1]

[1]Staatliches Museum für Naturkunde Stuttgart, Stuttgart, Germany, [2]Museum für Naturkunde Berlin, Berlin, Germany, [3]Senckenberg Centre for Human Evolution and Palaeoenvironment at the Universität Tübingen, Tübingen, Germany

Paleopathologies have been described for many different groups of animals from the fossil record, including dinosaurs. The described conditions range from gout, to cancer, infections, bite traces and traumatic injuries and can tell us a lot about the lifestyle of groups of animals and the life histories of specific individuals. Within Dinosauria the majority of pathologies described is on theropods and derived ornithopods. Pathologies described in Sauropodomorpha appear to be less common and most of them are located in the caudal region. Only two pathologies have been described in basal sauropodomorphs. The first is a pathological tail of *Massospondylus carinatus* that was possibly amputated and the second is a potential bite wound in a rib and osteomyelitis in *Lufengosaurus heunei*. Here we present the first paleopathologies from *Plateosaurus trossingensis*, the best known early sauropodomorph. Over 100 relatively complete individuals have been excavated from different Late Triassic localities. However, no information on any pathologies within *Plateosaurus* have ever been published. We present pathologies in the chevrons of three specimens of *P. trossingensis*, including the type specimen. In both SMNS 13200 and SMNS 91269 we have three consecutive chevrons and in GPIT-PV-30785 single chevrons, all with lesions on their distal ends. SMNS 91269 chevrons show a very clear complete, traumatic break with displacement and healing of the bone. SMNS 13200 has potential damage to the periost, and GPIT-PV-30785 has some still unidentified pathological overgrowth. Using micro-CT scanning we will gain further information about these pathologies. The bone microstructure will show the exact anatomy of the break in SMNS 91269 and will help us to better understand the formation of reactive bone and possibly the cause of the break. It will further allow us to study the microstructure of the callus in the other two specimens to further identify the nature of the pathologies and better constrain the potential causes.

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Colbert Poster Prize Session

**CHANGES IN SMALL MAMMAL COMMUNITIES OVER THE PAST 25,000 YEARS SHOW A COMPLEX RELATIONSHIP BETWEEN COMPOSITION, TRAITS, AND ARIDITY**



Schap, Julia[1], Meachen, Julie[2], McGuire, Jenny L.[3]

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Many ecosystems today face increasingly frequent and extreme droughts, which are the leading climate change concern globally. Small mammals can be harbingers of larger ecological changes, making them critical components for conservation. We use the fossil record to explore how small mammal communities respond to aridity changes. Recent, short-term droughts in California caused small mammals to increase in evenness, as dominant generalist species suffer severe population fluctuations. It has also been hypothesized that with increasing aridity, herbivore tooth crown heights increase to combat wear. Here, we examine community-level changes, including evenness, hypsodonty, and diet across a series of arid-semiarid cycles. We compare Natural Trap Cave (NTC), Wyoming, which is open and arid, and Samwell Cave (SC), California, which is closed and forested to see if these changes are consistent across landscapes. Evenness decreased at both caves from the Late Pleistocene to the Late Holocene. At NTC, dietary generalists were more common in the arid Pleistocene (61%) with folivores dominating in the Middle (62%) and Late Holocene (57%). However, at SC generalist taxa increased into the Holocene. The Pleistocene community at NTC had the highest percentage of taxa with low tooth crown heights (42%) halving into the Holocene. Communities at SC were dominated by low crowned taxa across all time periods, largely driven by an abundance of *Peromyscus*. Changes in hypsodonty and a shift from generalist to folivores at NTC do not align with anticipated responses to aridity, which decreased from the Pleistocene to the recent. Functional relationships of these communities to aridity may be more nuanced than previously thought. Bioavailability of water and local vegetation types at NTC can help parse out these trends. Pleistocene precipitation mostly accumulated during the winter, not aiding plant growth. Thus, generalist mammals who could survive on scant, arid-adapted plants and invertebrates, such as *Peromyscus* and *Neotoma*, dominated. Precipitation through the Holocene shifted to summer accumulation, allowing plants, like grasses, to colonize and folivores to increase in abundance with corresponding shifts to high crowned communities. This change in precipitation accumulation may also have led to more favorable soil for burrowing taxa, like *Thomomys*, *Microtus*, and *Lemmiscus*, which increased in abundance in the Holocene causing an increase in community average crown height.

**Funding Sources** National Science Foundation CAREER award [EAR/SGP 1945013], National Science Foundation grant [EAR/SGP 1425059], and National Geographic Society grant [9479-14]

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Technical Session 2: Early Mammals & Carnivora (Wednesday, October 18, 2023, 8:00 AM)

## THE EARLY FOSSIL RECORD AND DIVERSIFICATION OF SHORT-FACED BEARS (URSIDAE, TREMARCTINAE) IN NORTH AMERICA

Schubert, Blaine W.[1], Samuels, Joshua X.[1], Soibelzon, Leopoldo H.[2], Wallace, Steven C.[1], Bogner, Emily[3]

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Previous research suggested that short-faced bears, also known as tremarctines, first appear in the North American fossil record ~7 Ma, with the earliest occurrence from the Rattlesnake Formation of Oregon. Though assigned to *Plionarctos*, re-examination of the Rattlesnake material (a partial dentary with worn m2) indicates the identification is not supported at the genus level. The next oldest tremarctine occurrence is from the Mt. Eden Formation of California, dated ~5.6 Ma. From this locality, a fragmentary and worn M2 and partial M1 represent the holotype (and genotype) of *Plionarctos edensis*, and a P4 and two m2s were referred to this taxon from the same locality. A second species of *Plionarctos, P. harroldorum*, was described from the early Blancan age Ringold Formation of Washington (~5 – 4.6 Ma), and previous researchers considered it to be a descendent of *P. edensis*. Re-examination of material assigned to *P. edensis* and *P. harroldorum* from the aforementioned sites reveals that some teeth are actually more like *Tremarctos* than *Plionarctos*. These specimens suggest that a *Tremarctos*-like tremarctine existed earlier than previously thought, and that short-faced bears were differentiated into two distinct lineages by the early Pliocene. Currently, the most complete craniodental material of *Plionarctos* is from the Gray Fossil Site (GFS) of northeastern Tennessee, originally considered to be ~7 – 4.5 Ma, with the older aspect of the range based on the record of *Plionarctos* from the Rattlesnake Formation. With the latter identification unsupported, and in conjunction with recent biochronological work at GFS, the former is now estimated to be ~4.9 – 4.5 Ma; roughly contemporaneous with other early occurrences of *Plionarctos*. Together, these records point to diversification and widespread dispersal of short-faced bears early in their history.

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Paleontological Management Poster Session (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

## CITIZEN SCIENCE AND PROFESSIONAL PALEONTOLOGY: THE DUTCH EXAMPLE

Schulp, Anne S.[1], Eijkelboom, Isaak[1], Reumer, Jelle W.[2]

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Citizen scientists (‘amateur fossil collectors’) had, have, and will have an important role in (vertebrate) paleontology. Intrinsically motivated, their thousands of extra pairs of eyes on the ground ensure that many more fossils are recovered, rather than falling prey to erosion or quarrying. The relationships between the citizen scientist community and professional paleontologists are shaped differently in different countries, depending on the strictness or liberty in paleontology-specific legislation. Restrictive legislation may push collecting activities underground, and lack of legislation may see scientifically important material legally disappear via commercial markets.
Here, we present our experience in the relationships between the citizen scientists and professional paleontology in the Netherlands – a country lacking specific legislation on paleontological heritage. This lack leaves the creation and maintenance of intrinsically motivated connections between the amateur collectors’ communities and the professional field a driving force in Dutch paleontology.

We have many examples where amateur collectors contribute collections or single fossils of outstanding quality to be prepared, studied, published, and accessioned in public repositories. The National Natural History Museum Naturalis in Leiden and museums in Rotterdam, Maastricht and Middelburg curate rich collections of fossils originating from amateur collectors’ activities. The record spans a wide stratigraphic range, from Carboniferous plants, Triassic vertebrates, Cretaceous (type Maastrichtian) material, and Miocene to Pleistocene mammals and mollusks. Often, support is provided by quarry or plant owners.

In addition, the Netherlands has a flourishing community of societies that bring together amateurs and professionals, such as the Working Group Pleistocene Mammals (WPZ), the Working Group Tertiary and Quaternary Geology (WTKG), the Netherlands Geological Society (NGV), and the Paleobiological Circle. Such gremia stimulate professionality among citizen scientists and contribute to the success of Dutch paleontology through a productive and diverse output. Of special note is the oervondstchecker.nl web portal, which not only facilitates interaction between amateur collectors and professionals, but nowadays also serves as a test bed for AI image recognition in fossil identification. Including AI as a learning tool with instant feedback would elevate citizen science participation even further.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

## DENTAL MICROWEAR TEXTURE ANALYSIS OF SYMPATRIC SPECIES OF BASAL UNGULGATES (MAMMALIA, PHENACODONTIDAE) FROM EARLY PALEOGENE NORTH AMERICA

Schwartz, Andrew F.[1], DeSantis, Larisa[2], Scott, Robert S.[1]

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Late Paleocene and early Eocene mammal communities in North America were a mosaic of taxa from archaic and modern families. Among the most common were representatives of the stem-perissodactyl family Phenacodontidae, formerly of ‘Condylarthra’. In sediments bracketing the Paleocene-Eocene Thermal Maximum (PETM) in western North America are species belonging to the genera *Ectocion* and *Copecion*. These small ungulates were roughly the same size (6-12 kg), had similar morphology, and likely occupied similar herbivorous niches. Additionally, both show considerable body mass reduction across the PETM, possibly in response to temperature and floral changes. Dental Microwear Texture Analysis was conducted to identify possible dietary differences between these taxa, as well as any changes in diet over time. No significant differences in dental microwear were found in sympatric species of *Ectocion* (n=13) and *Copecion* (n=8). This suggests that neither food hardness nor toughness were significant factors in niche partitioning between stem-ungulates in Paleocene-Eocene North America. Conversely, significant differences in complexity were found between *Ectocion osbornianus* (n=13) and the diminutive PETM taxon *Ectocion parvus* (n=6). These data suggest greater brittle-object mastication in *Ectocion parvus*, hinting at a potential adaptive shift to changes brought about by the PETM.

**Funding Sources** Center for Human Evolutionary Studies (CHES), Rutgers University

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

## THE PALEOCENE-EOCENE THERMAL MAXIMUM IN THE TOGWOTEE PASS AREA, WYOMING, USA

Secord, Ross

Earth & Atmospheric Sciences, University of Nebraska-Lincoln, Lincoln, Nebraska, United States

The onset of the Paleocene-Eocene Thermal Maximum (PETM) marks the Paleocene-Eocene boundary. The boundary is recognized by a large, negative carbon isotope excursion (CIE), caused by a massive release of carbon to the atmosphere. Mammalian faunas underwent major reorganization during the PETM as the earliest known species of Perissodactyla, Artiodactyla, Euprimates, and other clades dispersed among North America, Europe, and Asia. The Bighorn Basin in Wyoming preserves a detailed record of faunal changes during the PETM but very little is known from other North American basins. To test whether fossiliferous records across the PETM were preserved in other basins, collecting crews from the University of Nebraska visited areas bearing previously described latest Paleocene (Clarkforkian) and earliest Eocene (early Wasatchian) faunas, including near Togwotee Pass in the Absaroka Range of Wyoming. Faunal lists for Togwotee Pass have been published but without locality information or stratigraphy. Three previously described collecting areas (Purdy Basin, Red Creek, and Hardscrabble Ridge) were relocated, in addition to several undescribed localities (e.g., Packsaddle Creek). Soil carbonates were collected from stratigraphic intervals that might preserve PETM age strata. A 4‰ CIE lasting for 19 meters of section was located along Packsaddle Creek, presumably representing the PETM. Mammal fossils occur below it but not in it. Based on excursion $\delta^{13}C$ values from Packsaddle Creek, variegated paleosols above Clarkforkian localities in Purdy Basin preserve part of the PETM. Two specimens of *Ectocion parvus*, a species confidently known only from the PETM, were included in published faunal lists from Purdy Basin. These specimens likely came from this level. Beds between Red Creek and Hardscrabble Ridge appear to preserve a thick section of mostly Clarkforkian age strata but exposure is poor. Specimens of *Ectocion osbornianus*, a common late Paleocene species, were collected from two exposures along this transect. Part of the PETM is preserved in a small, isolated outcrop stratigraphically below the base of the Hardscrabble Ridge section, based on low $\delta^{13}C$ carbonate values. Stratigraphically higher localities on Hardscrabble Ridge yielded early Wasatchian mammals. This PETM site bears fossil bone but no mammals were found. In summary, the PETM CIE is present at three sites in the Togwotee Pass area, but no new mammals were found within PETM strata.

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Virtual Posters

### MULTI-PROXY DIETARY RECONSTRUCTION OF DERIVED EQUINAE FROM THE MIOCENE THROGH THE PLIO-PLEISTOCENE OF NORTH AMERICA

Semprebon, Gina M.

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Dietary proxies with different temporal resolutions were employed to provide a comprehensive dietary reconstruction of North American fossil equid taxa spanning from the late Miocene (Clarendonian) through the Pleistocene (Rancholabrean). Hypsodonty, mesowear, and microwear trends were studied on derived Equinae. These results were then compared to three extensive extant ungulate tooth wear databases. Results show that in the early Miocene, derived Equinae underwent a consistent increase in hypsodonty and mesowear scores (abrasion indices) and continued this trend through the Pliocene and Pleistocene but declined slightly in the Recent. A microwear abrasion index, scratch texture, mirrored hypsodonty and mesowear trends, but microwear alone turns over rapidly enough to reveal the actual dietary reason for these shifts in abrasion. In the early Miocene, microwear scratch number results show that hypsodonty and mesowear trends toward greater abrasion were due to the derived Equinae engaging mostly in high-abrasion grass consumption but as grazers and mixed feeders. In the late Miocene, the derived Equinae continued with coarse microwear scratch textures and continued the trend toward engaging in both grazing and mixed feeding. This dietary trend continued into the Pliocene, but in the Pleistocene, only one species in the genus *Equus* studied here had microwear consistent with pure grazing, although deeper time mesowear and hypsodonty proxies had values that are more consistent with grazing in extant forms. High degrees of microwear pitting and gouging were more accelerated from the early Miocene onward indicating exposure to exogenous grit on food items and most likely explaining the extreme acquisition of hypsodonty and blunter mesowear cusps in equids compared to other North American ungulate families. This acquisition of hypsodonty set the stage for the Equidae to become the only hypergrazer North American family in the Recent. Results here underscore the vital importance of utilizing more than one dietary proxy to provide enough information to reconstruct paleodiet with assuredness.

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Technical Session 12: Methods & Paleohistology (Friday, October 20, 2023, 8:00 AM)

### *FOSSILSCOPE*: LIFTING THE VEIL ON THE UNDERLYING DATA AND MANIPULATIONS YIELDING 3-DIMENSIONAL SKELETAL AND FLESH MODELS

Sereno, Paul C.[1], DeVries, Raina P.[1], Myhrvold, Nathan P.[2], Baumgart, Stephanie L.[1], Vidal, Dan[1], Keillor, Tyler[1], Conroy, Lauren L.[1]

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Three-dimensional (3D) digital restoration is central to vertebrate paleontological research today, driven by laser and tomographic computed (CT) scanning and stereophotogrammetry. The restoration process usually involves multiple fossil specimens that have been repaired, mirrored or resized, and is often guided by 3D renderings of the skeletons of modern analogs. Documentation is often minimal for the myriad decisions involved to generate the final skeletal model. Likewise, 3D digital flesh renderings, either by themselves or fashioned over 3D digital skeletal models, are often presented as a *fait accompli*, largely undocumented and usually impossible to precisely reproduce. The flesh restoration process often involves study or reconstruction of muscle masses or fleshed out body volumes based on CT scans of multiple modern analogs. Documentation of muscle attachments/volumes or flesh body partition volumes/densities are usually piecemeal. We need a means to efficiently link a range of specimens, images, data and an account of manipulations directly to final skeletal or flesh restorations. Using freeware we introduce here an interactive application, *FossilScope*, developed in the Unity game engine using Blender. By clicking or dragging a cursor over a skeletal or flesh model rendering, one may select a bone or bone complex (e.g., dentary, skull), a muscle or body partition (e.g., m. caudofemoralis, hind limb) to access a range of associated information, including the basis or rationale for that particular rendering as well as associated photographs, CT scans or other data. The 3D skeletal or flesh model may be color-coded to highlight the status (e.g., unrestored) or origin (e.g., holotype) of components of the restoration. We demonstrate the utility of *FossilScope* in real time at the podium by unveiling the specimens used and decisions taken to complete recent skeletal and flesh renderings of the nonavian dinosaur *Spinosaurus aegyptiacus*. *FossilScope* facilitates direct access to specimens and actions taken during 3D restoration, providing intuitive, cost-free access to the science underlying the most complex and frequently-referenced iconography in paleontology —3D skeletal and soft anatomical restorations.

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Technical Session 16: Theropods - I (Saturday, October 21, 2023, 8:00 AM)

**FIRST DIGITAL FORELIMB RECONSTRUCTION AND RANGE OF MOTION ASSESSMENT OF THE LATE CRETACEOUS DINOSAUR *TROODON FORMOSUS*: NEW RESULTS**

Serio, Michael, Varricchio, David J.

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*Troodon formosus* (*Troodon*) is a theropod dinosaur from the Late Cretaceous of North America primarily known from fragmentary fossil material within the Judith River and Two Medicine formations. Hypothesized to be a small game hunter, *Troodon*, like many theropods, may have actively engaged its forelimbs to aid hunting behavior. Furthermore, the complexity of preserved nests associated with *Troodon* suggest it had sufficient range of motion and dexterity to use its forelimbs to manipulate its eggs. Additionally, *Troodon's* evolutionary position as one of the closest groups to living birds could indicate important information about the evolution of the avian wing. However, no complete forelimb material has yet been found for *Troodon*, and as such a complete reconstruction and range of motion (ROM) estimate of its forelimbs has yet to be attempted. This study aims to address these hypotheses and shortcomings by leveraging recent digital modelling technology to create the first forelimb reconstruction and ROM for *Troodon*.

To overcome preservation limitations, surface scans from multiple *Troodon* fossils housed in the Museum of the Rockies (Bozeman, Montana) were digitally combined to reconstruct most of a forelimb. From this model, digital articulation in the software package Maya was compared with physical articulation ROM methods using 3D printed copies of the reconstructed forelimb. The maximum angle of allowed motion for each forelimb joint until bone-on-bone contact was assessed.

Results show increased flexion over extension in *Troodon's* joints, consistent with closely related species. However, *Troodon* also shows higher manual extension than close relatives. The humerus is also shorter and stockier, showing mechanical specialization for strength vs speed, and convergent features with primitive theropod species. These ROM and morphological differences imply a deviation in hunting strategy or forelimb utility and show a deviation from avian forelimb morphology. Total manual ROM results cannot confirm whether *Troodon* was able to grasp its eggs and small prey single-handed, but two-handed apprehension remains feasible.

This study utilized digital and physical ROM methods, analyzing for the first-time specimens that would have been previously overlooked. These results shed light on both the foraging and reproductive behavior of *Troodon* and have implications for understanding the evolution of modern avian reproductive behavior and the dinosaur-bird transition.

**Funding Sources** Funding for this project is provided by the Jack Horner Paleontology Scholarship, and a Paleontological Society Student Research Grant.

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Education & Outreach Poster Session (Saturday, October 21, 2023, 4:30 - 6:30 PM)

### CHEWING ON CHANGE: TRAINING THE NEXT GENERATION OF SCIENCE COMMUNICATORS

Sharma, Divya[1], Killingsworth, Stephanie[1], Bokor, Julie[2], Pirlo, Jeanette[3], Abramowitz, Brian[1], MacFadden, Bruce J.[1]

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The Chewing on Change (CoC) K-12 curriculum was designed to unite University of Florida (UF) student science-content experts and public school teachers in order to improve science education in Florida public schools. A series of hands-on lessons, aligned to Florida State K-12 Standards, were designed and implemented in collaboration with teachers and scientists. Students used 3D printed horse teeth from the Florida Museum Vertebrate Paleontology collection to explore evolutionary changes over time. Visualizing these changes allowed students to better comprehend evolutionary processes, compare orthogenetic to phylogenetic evolution, and the scale of geological time. Though this lesson was designed for 8th-12th graders, a modified version was adapted for 4th grade, introducing a topic that most children do not learn until higher grades.

The active learning aspect of this project made it a great success for all involved. Students learned how evolution works in an accessible manner. Some schools do not have a strong evolution curriculum, and this lesson fills in these gaps in K-12 science standards. Qualitative assessment data were collected from the participants to determine program outcomes and efficacy. Inviting scientists from diverse, interdisciplinary backgrounds into the classroom also introduces students to near-peer role models and various STEM careers, helping them envision their own goals for the future.

Four UF student scientists from different majors were trained on the CoC curriculum during professional development and related follow-up activities during the school year (2022-2023). This innovative approach of training undergrads from different disciplines also allowed for an exploration of STEM careers and science communication in multiple areas. This is a rare but valuable opportunity that most students do not get until graduate school. Pairing student scientists with K-12 teachers allows them to experience what an education-based career would be like and if it suits them, along with learning about other opportunities within science education. Communication is a key part of science and exposing students to this early in their careers allows them to develop the necessary skills in order to become a better scientist. Chewing on Change has benefited undergraduate student scientists, public school teachers, and K-12 students by better integrating science into their daily lives and increasing their opportunities for better science communication.

**Funding Sources** Paleontological Society, Alachua County School District, Scientists in Every Florida School

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Technical Session 3: Fishes & Amphibians (Wednesday, October 18, 2023, 8:00 AM)

### PECTORAL JOINT OF DEVONIAN ANTIARCH FISHES PRODUCED STRIDULATING SOUNDS

Sharma, Neelima, Haridy, Yara, Shubin, Neil

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Antiarchs, a diverse and successful group of placoderms that spanned from the Silurian to the end Devonian, were characterized by an arthropod-like pectoral joint geometry. The function of the distinctive antiarch pectoral fin has remained obscure, with suggestions of their importance in maneuverability, anchoring, walking, and defensive behavior by engaging in an anti-predatory display by fin adduction. A high-resolution micro-CT scan of the pectoral fin of the antiarch, *Asterolepis* sp., revealed that the articular surface texture of the fin is similar to the ridges and honeycomb processes found in the articular surface of the fin spine of the modern siluriform catfish. Catfish are known to rub their pectoral spine against a groove in the pectoral girdle to produce stridulating sounds, a behavior is

commonly referred to as 'talking'. Here, we investigate a potential secondary function of the antiarch fins, the production of stridulating sounds by rubbing the articulating surface of the fin against the pectoral shield.

To understand the relationship between surface texture and acoustic signals, we first compared the surface roughness of the pectoral fin joints in catfish and antiarchs by collecting high-resolution data using micro-CT scans of pectoral joints of several species of each group. Although the overall morphology of the joint is significantly different between antiarchs and catfish, both exhibit remarkable similarity in the structure of ridges and honeycomb textures on the articulating surface of the pectoral fin. Preliminary analysis shows that antiarchs exhibit a greater roughness, measured as the slope between the variance of the surface texture with the length scale, compared to the catfish samples.

The fin has a central cavity and a curved shell-like geometry that likely assists in the conversion of the vibrational frequency due to contact dynamics to the acoustic mode by minimizing energy losses and making the fin behave like a resonance vibrator. Based on the preliminary analysis and the convergence of surface texture in catfish and antiarchs, we predict that antiarchs likely used their fins for producing stridulations. Our results have implications for the acoustic complexity of ancient aquatic environments.

**Funding Sources** Thanks to University of Chicago, HFSP, and Brinson Foundation.

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Colbert Poster Prize Session

## AN ENTHESEAL ORIGIN FOR THE HADROSAUR (ORNITHISCHIA: HADROSAURIDAE) JUGAL FLANGE

Sharpe, Henry S.[1], Dudgeon, Thomas[2]

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Hadrosaurs were a group of herbivorous dinosaurs known for their complex dentition that facilitated efficient chewing. Hadrosaurs, as well as derived ornithopods, possess a rounded caudoventrally-oriented flange on the jugal bone that is used to code multiple characters in phylogenetic analyses. Currently, the function of this flange is unknown, though an insertion for the pterygoideus ventralis muscle has been proposed. Bone texture on the posterolateral and posteromedial surfaces of this feature is consistent with proposed entheses elsewhere on hadrosaur skeletons (e.g., the deltopectoral crest, fourth trochanter). These include parallel striations and a rugose posterior border in large specimens. Some specimens show small spurs projecting from the posterior border, possibly indicating a pathology. To further test whether this flange represents a soft tissue attachment site, we histologically sampled the jugal of *Edmontosaurus regalis*, revealing a high density of posteroventrally-oriented Sharpey's fibers on the flange that are not observed in a control sample taken from the orbital margin. These fibers are visually similar to those recorded in muscle attachments, ligament attachments, and articular cartilages, of which only the first two options are viable since the jugal flange does not articulate with other bones. These surface and histological features on the jugal are directed posteroventrally towards the laterodorsal flange on the surangular and the ventral quadratojugal flange on the quadrate. These features exhibit similar rugosities to the jugal flange and may represent insertion sites for this proposed soft tissue structure. Therefore, our results suggest that hadrosaurs likely possessed a ligament or muscle connecting the jugal to the quadrate and mandible. The former would represent convergence with squamates that have modified the quadratojugal ligament to stabilize the mobile quadrate during feeding. The latter would represent convergence in chewing musculature between hadrosaurs and mammal-line synapsids. Preliminary examinations of other dinosaur jugals support homology of this soft-tissue feature throughout Ornithopoda, and possibly in marginocephalians, sauropods, and theropods. This would have broader ramifications in the reconstructions of feeding and associated soft tissues in dinosaurs and will be further investigated with histological sampling of a broad phylogenetic range of dinosaurian jugals.

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

## A MARINE VERTEBRATE FAUNA OF THE LOWER BRUSH CREEK LIMESTONE (CONEMAUGH GROUP: CARBONIFEROUS, GZHELIAN) OF OHIO

Shell, Ryan[1], Cline, Daniel A.[2], Cheshire, Jamie[2], Ciampaglio, Chuck[2], Fuelling, Lauren[2]

[1]Department of Vertebrate Paleontology, Cincinnati Museum Center, Cincinnati, Ohio, United States, [2]Department of Science, Mathematics, and Engineering, Wright State University - Lake Campus, Celina, Ohio, United States

The rocks of the Conemaugh Group of the Appalachian Basin were deposited by periods of climate-dominated sea level change in the late Carboniferous Period. The Kasimovian (307 – 303.7 million years ago) Lower Brush Creek Limestone (Glenshaw Formation) represents the first marine transgression within the Conemaugh Group. Bulk samples were collected from an exposure of the Lower Brush Creek Limestone in Morgan County, Ohio, washed with diluted formic acid, and vertebrate microremains extracted from the dissolved sediment. This initial investigation into the site has identified 7 distinct taxa of marine vertebrates. This fauna consisted of symmoriiform chondrichthyans (*Stethacanthus*, *Denaea*), ctenacanthiform chondrichthyans (*Glikmanius* sp., *Glikmanius myachkovensis*), Euselachians (*Cooleyella* sp.), eugeneodontiform chondrichthyans (*Agassizodus* sp.) and palaeonisciform osteichthyans (Palaeonisciformes indet.). A majority of these taxa are known from later marine units within the Conemaugh Group, which indicates that these taxa persisted across several intervals of sea level rise and fall.

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**PLACOID SCALES OF THE NEOGENE MEGATOOTH SHARK, *OTODUS MEGALODON* (LAMNIFORMES: OTODONTIDAE), AND THEIR BIOLOGICAL IMPLICATIONS**

Shimada, Kenshu[1], Yamaoka, Yuta[2], Kurihara, Yukito[3], Takakuwa, Yuji[4], Maisch, Harry M.[5], Becker, Martin A.[6], Eagle, Robert A.[7], Griffiths, Michael L.[6]

[1]DePaul University, Chicago, Illinois, United States, [2]Saitama Museum of Natural History, Nagatoro, Japan, [3]Mie University, Tsu, Japan, [4]Gunma Museum of Natural History, Tomioka, Japan, [5]Florida Gulf Coast University, Fort Myers, Florida, United States, [6]William Paterson University of New Jersey, Wayne, New Jersey, United States, [7]University of California at Los Angeles, Los Angeles, California, United States

The late Neogene megatooth shark, *Otodus megalodon* (Lamniformes: Otodontidae), that occupied a trophic position similar to, or possibly even higher than, the extant white shark (*Carcharodon carcharias*), is mostly known based on its gigantic teeth and vertebrae in the fossil record. In this study, we examined the rock matrix surrounding a previously described associated tooth set of *O. megalodon* recovered from the Tsuchishio Formation (early late Miocene; middle Tortonian) in Fukaya City (formerly Kawamoto Town) in northern Saitama Prefecture, central Japan, that is housed in the Saitama Museum of Natural History, Nagatoro, Saitama Prefecture, Japan. Our examination resulted in the collection of nearly 600 placoid scales, each measuring 0.3–0.8 mm in maximum dimension. All placoid scales were found individually disarticulated except for two scales remaining articulated, where each scale consists of an enameloid crown with a constricted base and a dentine root with a centrally located nutritive pore on the basal face. The collected placoid scales can be classified into three broad categories, two of which can each be further divided into two subcategories. More importantly, many placoid scales possess pronounced, rather broadly-spaced keels on the apical surface of the crown. Whereas the interkeel distances range from 75 to 130 µm, the most representative interkeel distance is ca. 100 µm. The presence of the rather broadly-spaced keels is significant because it indicates that *O. megalodon* was not a fast swimmer, contrary to the previous hypothesis that it was a fast-swimming shark like the extant lamnids (*Lamna*, *Isurus*, and *Carcharodon*). Therefore, we propose that *O. megalodon* was generally a slow-cruising shark with occasional burst-swimming for prey capture.

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Preparators' Session (Thursday, October 19, 2023, 8:00 AM)

**THE CHALLENGE OF HARD-TO-REACH SPACES IN MECHANICAL FOSSIL PREPARATION: DEVELOPMENT OF A NOVEL SHORT-BODIED AIR SCRIBE WITH A FLEXIBLE HEAD**

Shinya, Akiko[1], Wada, Kazumi[2], Tanaka, Tomonori[3], Ikeda, Tadahiro[3]

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Pneumatic air scribes are the primary tools used for mechanical fossil preparation, especially in vertebrate fossils. However, their long and straight, pen-shaped shafts (generally 100–150 mm in length) and fixed heads limit the working angle in narrow and hard-to-reach spaces, such as the intricate surfaces of pneumatic bones and inside deep cavities (e.g., sauropod vertebrae). Moreover, when preparing microvertebrate fossils (e.g., frogs, lizards, and small mammals), the limited working space for long air scribes between the microscope's objective lens and the fossil specimen restricts effective preparation. To overcome these challenges, we developed a novel short-bodied air scribe (Wada-type air scribe) constructed from hardware readily available at home improvement stores. The new Wada-type air scribe has an extremely short body (35 mm) and the handle with a hinge can be attached to make the working angle adjustable, allowing users to hold it in an ergonomically natural hand position during preparation. Despite its short body, performance of the newly developed Wada-type air scribe is comparable to conventional air scribes with a similar stylus size. In addition, the Wada-type air scribe can upcycle used styli that are too short to continue using in the conventional air scribe. Together with its maneuverability in the limited space, the novel configuration of the Wada-type air scribe overcomes disadvantages of the conventional air scribes.

We described herein a detailed, step-by-step materials and methods to build the short-bodied Wada-type air scribe, so that fossil preparators across the world can reproduce and use it. While most of the knowledge on fossil preparation techniques and methods has been shared by most palaeontological communities, unique and highly specialized preparation methods and techniques independently developed by local palaeontological laboratories and museums are rarely shared. We believe that the active publication and demonstration of in-house paleontological tools and methods further enhances the development of fossil preparation techniques and strengthens paleontological research.

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Technical Session 17: Afrotheria & Mammal Macroevolution (Saturday, October 21, 2023, 8:00 AM)

## MAMMOTH POPULATION MODELS: IMPLICATIONS FOR PALEOBIOLOGY AND CONSERVATION

Shirley, Ethan A., Fisher, Daniel C.

Earth and Environmental Sciences, University of Michigan, Ann Arbor, Michigan, United States

Woolly mammoths (*Mammuthus primigenius*) went extinct on mainland Siberia at the end of the Pleistocene. Mammoths' tusks retain faithful records of growth rate and chemistry that can help reconstruct much about their environments and behavior. Assessments of extinction risk in living elephants depend largely upon accurate life history parameters to project trends into the future, but life history parameters are not simple or static, and instead may change significantly in response to different stressors. Rate of reproduction, especially, may increase in response to predation, and decrease in response to deteriorating environmental conditions. In mammoths, we can use tusks to analyze life history traits through time as populations declined to better understand how elephant life histories may change in the future. Here we describe methods to determine reproductive life history in mammoths and model a hypothetical mammoth population to show combinations of different stressors and resulting changes in rate of reproduction that could lead to extinction. Absent catastrophic mortality events and human hunting, extinction is only possible with changes in reproductive rate that are almost never observed in modern elephants—calving intervals of more than ten years. We use these modeling results to create a simulation of three mammoth subpopulations experiencing simultaneous increasing pressure from human hunting and deteriorating environmental conditions. This case shows extinction is possible at higher reproductive rates than the ten-year calving interval when deteriorating habitat quality is conjoined with hunting. Because life history may change differently in response to different stressors, it is possible to evaluate different hypotheses of mammoth extinction based on different changes in life history through time, but simultaneous pressures from human hunting and environmental deterioration may obfuscate any effect of either stressor by itself. Currently, no mammoth tusks show evidence of reproductive rate slow enough to cause extinction, but there is evidence

of human harvesting of mammoths in Siberia. This suggests that hunting likely played a role in the decline of mammoths in Siberia, either independent of or in conjunction with environmental pressures. We conclude by emphasizing the importance of understanding changes in life history traits for conservation assessments of modern elephants, which may be more at risk than we previously thought.

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Technical Session 8: Mammal Paleoecology (Thursday, October 19, 2023, 1:45 PM)

### CHANGES IN CO-OCCURRENCE STRUCTURE OF NORTH AMERICAN MAMMAL PALEOCOMMUNITIES ACROSS THE PLIO-PLEISTOCENE TRANSITION

Shupinski, Alexandria[1], Smith, Felisa A.[2], Lyons, Kate[1]

[1]Biological Sciences, University of Nebraska-Lincoln, Lincoln, Nebraska, United States, [2]University of New Mexico, Albuquerque, New Mexico, United States

Understanding the structure and function of ecological communities is a central goal in ecology. One promising line of inquiry is using co-occurrence analyses to examine how species traits mediate co-existence and how major ecological, climatic, and environmental disturbances can affect this relationship, and underlying mechanisms. However, the impacts of disturbances on species associations can vary across functional groups. Here, we use the North American fossil record to evaluate the role of functional traits in co-occurrence of mammals during glaciation at the Plio-Pleistocene transition. We compiled 88 paleocommunities from two time periods: "pre-glaciation" (4–2.5 Ma) and "post-glaciation" (2.5–1 Ma). Genus-level co-occurrence was calculated to identify significantly aggregated (co-occur more than expected) and segregated (co-occur less than expected) species pairs, as well as association strength. Four traits were used to quantify functional diversity and functional distance between genus pairs was calculated to evaluate the relationship between pair type, association strength and functional role. Functional distance between significant pairs does not change post-glaciation, but we find a shift in average pair strength, resulting in overall stronger aggregations. Carnivores drive the shift, losing functionally similar aggregations and gaining aggregations between functionally dissimilar genera. This suggests the carnivore niche does not maintain the same level of functional redundancy following the glaciation event. Our study highlights the importance of functional roles in shaping co-occurrence after large-scale ecosystem disturbances.

**Funding Sources** National Science Foundation DEB 1257625

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Technical Session 18: Synapsids (Saturday, October 21, 2023, 8:00 AM)

### GORGONOPSIANS FROM THE PERMIAN OF ZAMBIA: PRELIMINARY DATA FROM THE LUANGWA AND MID-ZAMBEZI BASINS.

Sidor, Christian A.[1], Mann, Arjan[2], Kammerer, Christian F.[3], Levy, Fletcher[4], Angielczyk, Kenneth D.[5], Museba, Joseph[6], Peecook, Brandon R.[7], Smith, Roger M.[8], Tolan, Stephen[9], Viglietti, Pia[5]

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Fieldwork since 2009 has yielded an extraordinary collection of over 50 well-preserved gorgonopsian fossils from the Madumabisa Mudstone Formation of Zambia, including articulated material that sheds new light on the paleobiology and systematics of this iconic group of Permian carnivores. Previous reports of Zambian gorgonopsians have been restricted to taxonomic lists, with little in the way of voucher specimens or diagnostic features referenced. Moreover, recent revisions of gorgonopsian alpha taxonomy compound the uncertainty of previous identifications.

Our research has identified at least nine taxa in the upper Madumabisa rocks of the Luangwa Basin, and one taxon from the Mid-Zambezi Basin, all of which are Lopingian in age. Two tetrapod assemblages characterize the upper Madumabisa Mudstone Formation in the Luangwa Basin. The upper assemblage, which likely correlates with the lower

part of *Daptocephalus* Assemblage Zone of South Africa, yields large rubidgeines (e.g., *Dinogorgon*, *Rubidgea*) as well as *Smilesaurus* and some smaller-bodied forms tentatively ascribed to '*Dixeya'-like* and *Cyonosaurus*-like forms. The lower assemblage, which has been correlated with the *Cistecephalus* Assemblage Zone, includes *Aelurognathus* as the sole rubidgeine recognized, but a wider variety of medium (e.g., *Arctops*, *Lycaenops*) and small-bodied forms (e.g., *Scylacocephalus*). The only gorgonopsian taxon recovered from the Mid-Zambezi Basin thus far is *Gorgonops*. Its fossils co-occur with those of the dicynodont *Endothiodon*, suggesting an *Endothiodon* Assemblage Zone-equivalency for this part of the formation. Diagnostic gorgonopsian material has yet to be recognized from the underlying Guadalupian portion of the Madumabisa Mudstone Formation.

The newly recovered fossils provide insights on a wide variety of aspects of gorgonopsian evolution. For example, data from *Aelurognathus* contributed to an analysis of pectoral evolution in synapsids and the first complete articulated pes of a gorgonopsian demonstrated that therapsids retained the ancestral phalangeal formula longer than previously suspected. In addition, computed tomography of *Lycaenops* resolved some previously unrecognized internal features, such as an incompletely ossified vertical septum of the vomer. Minor morphological variation suggests the presence of endemic species for some of the genera recognized, but this awaits formal phylogenetic testing.

**Funding Sources** NSF EAR-1337569, NSF EAR-1337291, National Geographic 158R-18

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Technical Session 10: Euarchontoglires & Xenarthra (Friday, October 20, 2023, 8:00 AM)

### A NEW GENUS AND SPECIES OF NOTHARCTINE PRIMATE (ADAPOIDEA) FROM THE EARLY EOCENE OF THE SAN JUAN BASIN, NEW MEXICO

Silcox, Mary T.[1], Selig, Keegan R.[2], Williamson, Thomas[3], Schillaci, Michael[1]

[1]Anthropology, University of Toronto, Scarborough, Toronto, Ontario, Canada, [2]Dept. of Evolutionary Anthropology, Duke University, Durham, North Carolina, United States, [3]New Mexico Museum of Natural History & Science, Albuquerque, New Mexico, United States

Adapoidea is one of the first groups of likely crown primates to appear in the fossil record, emerging ~56 million years ago at the beginning of the Eocene and known from across Laurasia. Most workers consider adapoids to be stem strepsirrhines. Although there are literally thousands of fossils of adapoids known from early Eocene deposits in North America, the record from the San Juan Basin (SJB) of New Mexico is notable for documenting a broad diversity of different adapoid species from a relatively narrow time window (Wasatchian North American Land Mammal Age 6). The current study documents an additional SJB genus and species known from a complete lower dental series (NMMNH P-80481), including well preserved spatulate incisors and a diminutive vestige of p1. While being similar in many ways to *Cantius*, the new genus has autapomorphous dental proportions, with an m3 that is shorter relative to the m2, and a p4 that is both longer and broader relative to p3 than in other notharctines. In a cladistic analysis, the new genus fell out as the sister taxon to a clade including *Notharctus*, *Smilodectes*, and *Copelemur*, and not as a close relative of any other San Juan Basin taxon, including *Pelycodus*, reflecting its mixture of primitive (e.g., unbasined p4 talonid), derived (e.g., reduced p1, expanded m2 paracristid) and unique (e.g., small m3 relative to m2) features. These analyses suggest the new genus represents a lineage distinct from other SJB adapoids. Dental topographic analysis suggests that the new genus was frugivorous, while analysis of enamel thickness indicates it was specialized for neither gummivory nor hard object feeding. This new taxon underscores the importance of the San Juan Basin to our understanding of the early phases of euprimate evolution, and of the diversification of Primates in North America.

**Funding Sources** Supported by an NSERC Discovery Grant to MTS.

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Technical Session 5: Ungulates (Wednesday, October 18, 2023, 1:45 PM)

### A PRELIMINARY SYSTEMATIC ASSESSMENT OF EARLIEST PALEOCENE NORTH AMERICAN "ARCHAIC UNGULATES" USING GEOMETRIC MORPHOMETRIC DATA FROM POSTCANINE DENTITION

Silviria, Jacqueline S.[1], Wilson Mantilla, Gregory[2]

[1]Department of Earth & Space Science, University of Washington, Seattle, Washington, United States, [2]Department of Biology, University of Washington, Seattle, Washington, United States

There is no consensus on the systematics of North American placental mammals from the early Paleocene, following the Cretaceous-Paleogene (K/Pg) mass extinction (66.051 Ma). Among the most controversial taxa are the first "archaic ungulates," which are common in local faunas referred to the Pu1 interval-zone of the Puercan North American Land Mammal Age (~66.051–65.820 Ma). Fifteen species are currently assigned to seven genera, but the number of valid taxa remains uncertain. Previous morphometric assessments relied on linear measurements and ratios from dentition, often to construct discrete characters for cladistic analyses. However, measurements and ratios were either insufficiently sampled or failed to provide statistically significant differences between proposed taxa.

Here we evaluate whether geometric morphometrics can help clarify the systematics of Pu1 "archaic ungulates." We use previously published 2D vertex data for 38 upper molars ($M^2$; 13 landmarks, 19 semilandmarks) and 44 lower molars ($M_2$; 12 landmarks, 20 semilandmarks) from 27 localities in the Fort Union Formation of Montana and Wyoming. Our sample includes specimens assigned to *Mimatuta minuial, M. morgoth, Oxyprimus erikseni, Protungulatum donnae, P. gorgun, R. engdahli*, and *R. nordicum*. Using the *geomorph* package in R, we superimposed configurations using the generalized least-squares Procrustes approach, then visualized molar morphospace via principal component analyses (PCAs). We also conducted maximum parsimony cladistic analyses of the superimposed configurations in TNT 1.6, with mean $M^2$ and $M_2$ shapes from 14 species of latest Cretaceous-earliest Paleocene eutherians serving as outgroups.

PCAs and cladistic analyses were only moderately successful in discriminating among Pu1 "archaic ungulate" taxa, especially using $M_2$ shape. This is partly due to high variability within the *Protungulatum* sample, and the lack of sampling for certain features (e.g., the $M^2$ hypocone apex). We are investigating whether adding vertices, sampling other premolar and molar configurations, and analyzing 3D instead of 2D configurations would improve results. Still, our preliminary analyses imply that some specimens provisionally assigned to *P. donnae* may be misidentified. This could lead to erroneous abundance and occurrence data used in paleoecological analyses (e.g., faunal evenness and richness estimates, species-level niche modeling) of the K/Pg transition in North America.

**Funding Sources** ARCS Foundation, Myhrvold and Havranek Family Charitable Foundation, UWBM Vertebrate Paleontology Graduate Fellowship, Willi Hennig Society Founders Award

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Education & Outreach Poster Session (Saturday, October 21, 2023, 4:30 - 6:30 PM)

## INSPIRING THE FUTURE QUEENS OF PALEONTOLOGY

Simon, Candice N.[1], Hunt-Foster, ReBecca K.[2], Snyder, Colton[3]

[1]Paleontology, North Carolina Museum of Natural Sciences, Raleigh, North Carolina, United States, [2]Dinosaur National Monument, Jensen, Utah, United States, [3]Office of Archeology and Historic Preservation, History Colorado, Denver, Colorado, United States

Dinosaur National Monument (DINO) hosted two separate day camp opportunities for Girl Scouts around the US in the summer 2022 and 2023, for ages ranging from 5-16 years old. The Girl Scouts had the opportunity to explore the natural wonders of DINO up close and personally, using scientific tools and techniques. These camps involved both in-class opportunities and field trips around the monument. The young women who participated in these camps were able to work alongside paleontologists and science communicators to learn more about the geologic history of the park, how fossils are excavated, how large dinosaurs were and how fast they were moving by analyzing tracks, made their own fossil replicas, and more! These lessons included the study of anatomy, geology, stratigraphy mapping, and fossil exploration, with visits to important paleontological sites such as the Carnegie Dinosaur Quarry Hall. These multi day camps provide a safe environment where these young women can ask questions and develop hands-on skills. Investing in the futures of these young women places them on a journey to become community leaders and to better understand the scientific process.

**Funding Sources** This project was funded by the National Park Service, with support from the Intermountain Natural History Association and Girl Scouts of Utah.

Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**TROPHIC ECOLOGY AND TAPHONOMY OF THE LOWER PERMIAN CRADDOCK BONE BED USING QUANTITATIVE ANALYSIS OF ASSOCIATED DIMETRODON SKELETONS.**

Simon, Holly[1], Donnell, Mckinzi[1], Stancik, Lauren[2], Vollmer, Evelyn[1], Flis, Chris[1]

[1]Paleontology Dept., Whiteside Museum of Natural History, Seymour, Texas, United States, [2]Midwestern State University, Wichita Falls, Texas, United States

A quantitative analysis of 4 *Dimetrodon* skeletons of varying completeness identified numerous consistencies and irregularities in expected patterns of carcass preservation in a low-energy fluvial channel deposit. Through quantitative analysis of associated and articulated specimens, predation and scavenging are identified as the primary agents of skeletal destruction followed by natural drifting of bones by low energy hydraulic forces. The high diversity, multitaxic Lower Permian Craddock bonebed (CBB) of Seymour, Texas has yielded tens of thousands of fossil bones of amphibians, reptiles, and synapsids since its discovery in 1907. The trophic ecology of the CBB is marked by a high frequency of scavenging and predation which contributes to the distribution of individual bones and complete skeletons within the deposit. Evidence of scavenger/predator-induced bone alterations such as tooth marks and dismemberment, and evidence of suspected invertebrate necrophagichnia contribute to the complex taphonomic activity observed at the CBB. *Dimetrodon* skeletons used for this study are WMNH123117 (Abby), WMNH063019 (Michael), WMNH32518 (Leigh), and WMNH042017 (Bonnie). These specimens range from little to no articulation (Abby) to full articulation (Bonnie) and were collected between 2016 and 2020 by the WMNH from site Kennesaw of the Craddock Bone Bed. Of the 4 specimens, none have complete tails; this conforms to predictable scenarios involving pre-mortem predation and post-mortem food processing in which the anatomical regions of highest muscle density are consumed first. Cranial elements are found separated along their natural sutural surfaces; articulated skulls of *Dimetrodon* are rarely found at this site, which is consistent with bone drift by low-energy hydraulic forces. Specimens displaying separation between successive centra in correct vertebral order while maintaining fully articulated necks is problematic. Lethargic hydraulic movement as a kinetic influence of disruption rather than predator/scavenger food processing is more likely in this situation. In concert with predictable scenarios involving pre-mortem predation and post-mortem food processing, 3 out of 4 skeletons lack limb bones and shoulder complexes, with Bonnie as the exception. In conclusion, a higher frequency of predator-altered bone than lethargic hydraulic disruption is suspected to be the primary agent of taphonomic influence.

Technical Session 17: Afrotheria & Mammal Macroevolution (Saturday, October 21, 2023, 8:00 AM)

**STABLE ISOTOPES CONFIRM NICHE PARTITIONING AMONG MORPHOLOGICALLY DIVERSE PALEOGENE HYRAXES (HYRACOIDEA; PLIOHYRACIDAE) FROM THE FAYUM, EGYPT**

Simpson, Emily M.[1], Crowley, Brooke E.[1], Borths, Matthew R.[2], Leichliter, Jennifer N.[3], Vonhof, Hubert B.[3], Lüdecke, Tina[3]

[1]Department of Geosciences, University of Cincinnati, Cincinnati, Ohio, United States, [2]Division of Fossil Primates, Duke Lemur Center, Duke University, Durham, North Carolina, United States, [3]Climate Geochemistry Department, Max Planck Institute for Chemistry (MPIC), Mainz, Germany

Egypt's Fayum Depression preserves over seven million years (from 37.4 to 29.8 MA), capturing an important window in hyrax evolution. Shortly after diverging from other afrotheres in the early Paleogene, hyraxes evolved diverse tooth shapes (bunodont, lophodont, and selenodont), postcranial morphologies (from cursorial to arboreal), and body masses (from <10 to >1000 kg). Only the small *Dimaitheirum* is known from the earliest Fayum deposit (37.4 MA), which was coastal. By 34.6 MA, a receding Tethys Sea resulted in a mosaic of forest and open habitat that supported eight morphologically diverse genera. By 33.8 MA, hyrax diversity decreased to three genera (small *Saghatherium* and *Thyrohyrax*, and large, scarce *Titanohyrax*), possibly due to competition with new proboscideans from elsewhere in Africa. Hyrax diversity recovered by 30.8 MA (five genera) and increased further by 29.8 MA (seven genera), likely

with expansion of denser forest.

We use enamel $\partial^{13}C$ and $\partial^{18}O$ to clarify what drove changes in hyrax diversity and further investigate niche partitioning among co-occurring genera. At 37.4 MA, *Dimaitherium* had high $\partial^{13}C$ values and low $\partial^{18}O$ variation, consistent with coastal habitat. Niche breadth increased at 34.6 MA as more genera appeared. Overall, these hyraxes had slightly lower $\partial^{13}C$, higher $\partial^{18}O$, and more variable values than *Dimaitherium*, consistent with a mosaic habitat. However, two *Megalohyrax* had high $\partial^{13}C$ (overlapping with *Dimaitherium*), suggesting continued presence of coastal habitat. Most larger hyraxes had higher $\partial^{13}C$ and $\partial^{18}O$ values than smaller ones. Niche breadth shrank by 33.8 MA when many hyraxes disappeared. Most sampled *Saghatherium* and *Thyrohyrax* had lower $\partial^{13}C$ and $\partial^{18}O$ than at 34.6 MA, consistent with denser forest. Niche breadth re-expanded at 30.8 MA; most taxa had low $\partial^{13}C$ and $\partial^{18}O$ (similar to 33.8 MA) but one *Thyrohyrax* had high $\partial^{18}O$, similar to 34.6 MA. Smaller hyraxes had higher $\partial^{13}C$ and $\partial^{18}O$ than larger ones. At 29.8 MA, all hyraxes had low $\partial^{13}C$ and $\partial^{18}O$ and smaller taxa had higher $\partial^{13}C$ and lower $\partial^{18}O$ values than larger ones (excepting *Bunohyrax*). Overall, tooth shape did not correspond with isotope values, but apparent differences between selenodont and bunodont taxa at 29.8 MA may reflect varying fruit consumption. In summary, our data confirm that early hyraxes responded to environmental change and help clarify ecological differences among taxa.

**Funding Sources** Funding provided by the NC Fossil Club, Cincinnati Dry Dredgers, Western Interior Paleontological Society, UC chapter of Sigma Xi, and UC Graduate Student Government.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

### A NEW SKELETAL SPECIMEN OF AN ENIGMATIC PLETHODID BONY FISH (ACTINOPTERYGII: TSELFATIIFORMES) FROM THE UPPER CRETACEOUS EAGLE FORD SHALE, TEXAS, USA

Skowronski, Marcelina A., Shimada, Kenshu

DePaul University, Chicago, Illinois, United States

Tselfatiiformes are an extinct group of small to medium-sized actinopterygian fishes that lived during the Cretaceous (Albian-Campanian). They consist of three families: Protobramidae, Eoplethodidae, and Plethodidae. Recently, a new tselfatiiform specimen, consisting of the anterior part of the fish including a nearly complete skull, was discovered from the lower Turonian part of the Upper Cretaceous Eagle Ford Shale in Frisco, Texas, USA. The specimen, DMNH 2023-01-01, is housed in the Perot Museum of Nature and Science in Dallas. The well-preserved anterior body of DMNH 2023-01-01 suggests that the fish was a deep-bodied form and estimated at 56 cm in total length based on the observed orbital-opercular length of 14 cm. It exhibits pectoral fins high upon the flank, well-developed preopercles, large infraorbital bones, and well-developed branchiostegal rays. These anatomical characteristics suggest its phylogenetic affinity within Tselfatiiformes. The left and right premaxillae are fused together but do not form a ‘snout.' The morphology of the fused premaxillae is reminiscent of the poorly known plethodid genus, *Plethodus*. Although further examination is necessary to determine its exact taxonomic identity, it is possible that DMNH 2023-01-01 may belong to a new taxon. Regardless, the specimen is important not only because almost all known plethodids are represented primarily by disarticulated incomplete remains but also because the morphological condition represented by the skull can be regarded as a precursor of the ‘snouted’ tselfatiiforms, such as *Thryptodus* and *Martinichthys,* characterized by an elongate, robust rostrum composed of fused premaxillae.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

### WHY WOODRATS GIVE ME NIGHTMARES: A PHOTOGRAPHIC ATLAS OF DENTAL MORPHOLOGY

Skwarcan, Stacie

Jackson School of Geosciences, The University of Texas at Austin, Austin, Texas, United States

Woodrats (*Neotoma*) are nearly ubiquitous in Late Pleistocene fossil deposits across the United States and Mexico. Occurrences in the fossil record are commonly reported; however, identifications for those occurrences are not always justified and often appear to be based at least in part on the modern geographic distributions of species. Published literature was reviewed for morphological characters used to distinguish species of *Neotoma* based on tooth rows and isolated teeth. In those published efforts to identify dental characters for distinguishing

species of *Neotoma*, no more than 8 of the 23 species that currently occur in North America were typically compared in a single study. Though inter- and intra-specific dental variation in *Neotoma* has been documented in the past, this work is an attempt to do so using larger sample sizes ($n$ = 30 per species, where possible) and including a sample of species not limited by modern geographic distributions.

The upper and lower dentition of 349 specimens of *Neotoma* housed in the collections at the Natural Science Research Laboratory at the Museum of Texas Tech University (TTU) were photographed, and published characters for distinguishing species of *Neotoma* were evaluated on photographs of those specimens. The sample of *Neotoma* from TTU includes 17 species, 8 of which were present in the collections in large enough numbers to photograph a sample size of $n$ = 30 per species. Preliminary data suggest that caution is warranted when identifying isolated *Neotoma* teeth to species due to variation in dentition.

This serves as a test of the traditional approach to identifying fossils of *Neotoma*, in which modern geographic distributions are used to limit the pool of species with which comparisons are made. It also provides a richer and more robust data set of morphological variation in the dentition of *Neotoma* and furthers our understanding of the limitations of morphological data for species identification when modern distributions are not used as a means of limiting the number of species with which comparisons are made.

This comparative data set will be used on material excavated from Phillips Paleo Cave in Crockett County, Texas. Processing of material from controlled excavations is ongoing, but *Neotoma* is an abundant taxon preserved within the cave. Within the top seven excavation levels, 467 isolated teeth, representing a minimum of 57 individuals, have been identified to *Neotoma*.

**Funding Sources** Lundelius Fund in Vertebrate Paleontology

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Technical Session 7: Birds (Thursday, October 19, 2023, 8:00 AM)

**TWO BIRDS WITH ONE STONE: THE TAPHONOMY OF FEATHER PROTEINS AND THE BIOCHEMICAL EVOLUTION OF FEATHERS**

Slater, Tiffany S.[1], Edwards, Nicholas P.[2], Webb, Samuel M.[2], Zhang, Fucheng[3], McNamara, Maria E.[1]

[1]Biological, Earth and Environmental Sciences, University College Cork, Cork, Cork, Ireland, [2]Stanford Synchrotron Radiation Lightsource, SLAC National Accelerator Laboratory, Menlo Park, California, United States, [3]Institute of Geology and Paleontology, Linyi University, Linyi, Shandong, China

Feathers of extant birds comprise primarily corneous beta proteins (CBPs; with β-sheet conformation) plus minor keratins (with α-helix structure). Feathers from fossil birds, non-avian dinosaurs and pterosaurs have the potential to inform on the evolution of feather chemistry, provided the original composition can be accurately inferred using appropriate techniques. Immunohistochemical analyses of feathers from the early bird *Eoconfuciusornis* reveal a keratin-rich feather composition, which is used as evidence of an evolutionary transition in feather chemistry from a keratin- to CBP-dominated state. Notably, the chemical signal is interpreted as original but does not consider feather taphonomy or test whether immunohistochemistry – a technique that relies on an immune response and is prone to false positives in archaeological studies – is appropriate for fossil analyses. Here we use Fourier transform infrared (FTIR) and sulfur-X-ray absorption near-edge structure (XANES) spectroscopy to probe the molecular structure of feather proteins during taphonomic experiments and in fossil feathers. We thermally matured black feathers from the domestic chicken (*Gallus gallus*) and white feathers from the little egret (*Egretta garzetta*) at temperatures up to 250°C for 1 hour. Our experimental data show that feather CBPs can survive moderate thermal maturation and support evidence of their preservation in *Confuciusornis* and *Sinornithosaurus.* This serves as the first robust evidence of protein remnants in the Mesozoic as our interpretations are grounded in a taphonomic framework. Critically, experimental data show that the predominantly β-sheet structure of CBPs is progressively altered to α-helices with increasing temperature. A keratin composition for fossil feathers is therefore best explained as a taphonomic artefact. The degradation of feather CBPs is shown to occur via a multi-step process, whereby initial loss of β-turns facilitates reconfiguration of β-strands into an α-helix conformation. This process is independent of geological age, as analysis of an isolated Cenozoic feather from a crown bird reveals a chemistry dominated by α-helices and disordered structures.

Collectively, this study suggests that modern feather biochemistry predates Aves and lays the foundation for future biochemical analyses of ancient, feathered animals.

**Funding Sources** This work was supported by ERC Starting Grant H2020-ERC-2014-StG-637691-ANICOLEVO awarded to M.E.M. and IRC New Foundations awarded to T.S.S.

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Technical Session 11: Archosaurs (Friday, October 20, 2023, 8:00 AM)

**EARLY DINOSAUR-DOMINATED COMMUNITIES FROM HIGH-RELIEF, SHALLOW, LAKE MARGIN ENVIRONMENTS IN LOW-LATITUDES (LATE TRIASSIC – EARLY JURASSIC, NEW JERSEY AND UTAH, USA)**

Slibeck, Bennett[1], Milner, Andrew[2], Olsen, Paul E.[1]

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Footprint assemblages from the NE and SW USA provide a high-resolution record of the aftermath of the end-Triassic Mass Extinction (ETE, 202 Ma) - key in the establishment of global dinosaurian ecological dominance. Here we compare two early paleo-low latitude dinosaur communities by tracing connections between the Woodland Park Assemblage (WPA) (uppermost Passaic Formation, Newark Basin, New Jersey) and the St. George Dinosaur Discovery Site at Johnson Farm Assemblage (SGDSA) (Whitmore Point Member, Moenave Formation, Utah). Both preserve records of ecosystems dominated by theropods with a striking dearth of herbivores. These hyper-low diversity assemblages suggest that early post-ETE dinosaur communities depended largely on aquatic trophic input, with dinosaurs subsuming roles once performed by phytosaurs, large pseudosuchians, and large temnospondyl amphibians. The sites have similar lithologies, dominated by red mudstones and sandstones produced by fluctuating, shallow marginal lake environments. WPA localities have abundant small scale clinoform ripple cross laminated beds with mud drapes suggestive of sheet deltas, and the SGDSA occurs associated with apparent megaripples. Both are unusual among footprint localities in having dinosaur tracks on the surface exhibiting relief, also preserving swim tracks and other uncommon behavioral features. An example of WPA theropod swim tracks are especially notable in showing a clear synchronous two-foot stroke. As noted by Milner and Kirkland and McDonald et al. isolated teeth of theropods from the lacustrine strata of the Moenave and post-ETE eastern North America are not as blade-like as many theropods, suggesting fish-eating, while the absence of any traces of herbivorous reptiles at the WPA and their extreme rarity at SGDSA suggests theropods were at least augmenting their diets with fish. The WPA postdates the palynologically-identified ETE by only a few thousand years, while the SGDSA is younger by at a hundred thousand years, suggesting that the association of theropods with these dynamic lacustrine environments was a persistent theme of early post-ETE dinosaur communities.

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Preparators' Poster Session (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**‘NATURE-FAKED’ LAY-UP URETHANE PLASTIC METHODOLOGY FOR SAFER HOLLOW-CAST MAKING**

Slovacek, Mariah

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Fossil casts are a valuable resource for study, display, and outreach. Polyester resin is often the preferred casting material due to its cost, ease of acquisition, high fidelity of detail, ability to make strong hollow casts with fiberglass, and relative ease of use. However, polyester resin has a relatively short shelf life, a dangerous catalyst (MEKP = Methyl Ethyl Ketone Peroxide), is difficult and expensive to dispose of safely, and off-gasses fumes well after cure.

The Perot Museum of Nature and Science until recently used polyester resin to create hollow casts of fossils for study and display. Recently, for a number of reasons, a large quantity of polyester resin expired before it could be used. The expensive waste of material combined with the costly process of safe disposal and considerations of future health and safety, cumulated in the decision that a different casting medium would be preferred. The main considerations in choosing a replacement material were: 1) the ability to create strong and accurate hollow casts; 2) ease of storage; and 3) be less hazardous chemically in both its unmixed form and

once cured. Two-part urethane casting plastic resin was chosen as the preferred alternative. Urethane is safer, has variable cure times, high fidelity of detail, and can be pigmented during the casting process. However, urethane is usually used to create solid pour casts, is strongly sensitive to humidity, and often lightens the hue of added colorants.

Initial tests to modify the lay-up casting method used Smooth-Cast 321 (pot life of 7-9 minutes) low viscosity urethane plastic, talc as a thickener, So-Strong urethane pigment, and fiberglass cloth. Results from this test indicated the technique was viable but needed refining. It had too short a pot life to apply layers into larger molds before the material began to cure, the colorant was not a good base for dark colored fossils that needed "nature faked" replicas, and talc trapped moisture causing foaming. Greater success is had with: Smooth-Cast 322 (pot life 10-20 minutes), cement pigment dusted onto the silicon molds with makeup brushes, and polyurethane thickener URE-FIL 11. The resulting hollow casts are light, strong, odorless, detailed, and visually appealing even before artistic painting.

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Technical Session 16: Theropods - I (Saturday, October 21, 2023, 8:00 AM)

## *BAGARAATAN*, OSMÓLSKA'S UNUSUAL THEROPOD DINOSAUR FROM THE NEMEGT FORMATION OF MONGOLIA PROVIDES NEW DATA ON THE EARLY ONTOGENY OF TYRANNOSAURIDS

Slowiak-Morkovina, Justyna[1], Brusatte, Stephen[2], Szczygielski, Tomasz[1]

[1]Institute of Paleobiology, Polish Academy of Sciences, Warsaw, Poland, [2]University of Edinburgh, Edinburgh, United Kingdom

In 1996, Halszka Osmólska described and named a new species of a theropod dinosaur, *Bagaraatan ostromi*, based on a bone association collected in 1970 in the Nemegt Formation of Mongolia. She considered it a medium sized tetanuran with unknown affinities, pointing out many similarities with Dromaeosauridae. Our reanalysis of the holotype of *Bagaraatan* revealed that the specimen represents a chimaera of three non-avian dinosaurs. The features of the femur are identical to *Elmisaurus rarus* from the Nemegt Formation in, e.g., the shape and position of the femoral head and accessory trochanter. The distal fibula is fused to the tibiotarsus, an autapomorphy of *Avimimus portentosus*, the second non-avian dinosaur identified in the assemblage. Finally, the last part of the assemblage, considered by us as the lectotype of *Bagaraatan ostromi*, consists of an incomplete mandible, pelvis, and vertebral series found in articulation in the field, which we identify here as a tyrannosauroid. The dentary shows a sharp Meckelian groove and a characteristic "chin" and the surangular shelf is well-developed along the long axis of the preserved posterior part of the mandible, indicating a close relation with Tyrannosauridae. *Bagaraatan* was scored in two phylogenetic datasets to assess its position among coelurosaurian theropods broadly and tyrannosauroids in particular. The former found the individual as immediately basal to Tyrannosauridae, and the latter within a polytomy at the base of Tyrannosauridae. Together with the small size of *Bagaraatan*, up to 3 m, this suggests that the individual was a juvenile. Indeed, many characteristics in the mandible of *Bagaraatan* are shared with juveniles of *Tyrannosaurus rex*, e.g., the $8^{th}$ tooth is the longest mesiodistally, the chin is lightly textured, the coronoid process is shallow, and the glenoid fossa is long and shallow. However, two features are unusual in *Bagaraatan*: the presence of two surangular foramina and a fused pubis and ischium. The latter may suggest that the fusion of the pelvic elements appeared early in the ontogeny of tyrannosaurids. The double surangular foramina are here considered as ontogenetically or intraspecifically variable. The bone wall below the anterior foramen is extremely thin, suggesting it was locally resorbed just prior to the entrance of a pneumatic diverticulum into the bone. Therefore, we conclude that the *Bagaraatan ostromi* lectotype is a juvenile tyrannosauroid, most likely a tyrannosaurid.

**Funding Sources** This research project is supported by the National Science Centre, Poland, grant no. 2019/35/B/NZ8/02292.

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Technical Session 8: Mammal Paleoecology (Thursday, October 19, 2023, 1:45 PM)

## COUPLED LANDSCAPE AND BIOTIC EVOLUTION MODEL REVEALS DEEP-TIME HISTORY OF THE TOPOGRAPHIC DIVERSITY GRADIENT

Smiley, Tara M.[1], Marder, Eyal[2], Yanites, Brian[2]

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Atmospheric Sciences, Indiana University, Bloomington, Indiana, United States

Modern biodiversity shows a clear correlation between complex topography and high biodiversity, a pattern known as the topographic diversity gradient. However, our understanding of the deep-time processes governing this relationship remains uncertain and requires collaboration between paleobiologists and earth scientists. To explore the conditions under which mountain biodiversity emerges and is preserved in the fossil record, we develop a novel numerical model that integrates biotic evolution from the population to species level, tectonic processes, erosion, and deposition. Model simulations are run across a range of uplift rates, beginning with a flat landscape and building a steady-state mountain range. The coupled model reveals temporal dynamics of species accumulation and resulting diversity patterns in the erosional mountain range versus adjacent depositional lowlands. We find that while species richness in the depositional lowland is consistently lower than in the mountain range, diversity patterns in the two settings are positively correlated across a range of uplift rates. We find that intermediate uplift rates characterizing most mountain ranges worldwide (~0.2-2.0 mm/year) produce elevated species richness in both the mountain range and depositional settings compared to low and high rates of uplift. The magnitude of tectonic uplift rate is related to the initial rate of speciation, with higher uplift rates resulting in rapid increases in species richness at the onset of mountain building. However, later declines in species richness at high uplift rates suggest a strong initial response to tectonic processes that may not be sustained through the history of mountain building. This finding is most pronounced at mid elevations but can also be observed in depositional lowlands. These results indicate that 1) elevated speciation rates and increased species richness due to the influence of mountain uplift and geomorphic processes can be recovered from the fossil record preserved in adjacent depositional lowlands, and 2) certain uplift histories promote stronger topographic diversity gradients than others. Future modeling efforts will investigate how superimposed climatic and biotic parameters during mountain building also govern the tempo and scaling of biodiversity and fossil preservation in dynamic landscapes. Data from modern and fossil records will be used to iteratively evaluate and improve the coupled modeling framework.

**Funding Sources** National Science Foundation Division of Earth Sciences, Program in Sedimentary Geology and Paleobiology Award #2041895 to PI Smiley and Co-I Yanites

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**AN INITIAL DYNAMIC MODEL OF LOCOMOTION FOR THE THERIZINOSAUR *NOTHRONYCHUS GRAFFAMI* (THEROPODA, MANIRAPTORA)**

Smith, David K.

Biology, Northland Pioneer College, Show Low, Arizona, United States

*Nothronychus graffami* was a large therizinosaur from southern Utah. Most of the appendicular skeleton is well-preserved with minimal taphonomic distortion. The pelvic girdle and hindlimb are convergent with those of many extant Neornithine birds. *Nothronychus* possessed an intermediately opisthopubic pelvis exhibiting altered osteology and muscle topology and function. A digitiform pose and anteroventrally rotated femur are assumed. This project presents a preliminary working model of locomotion in the hindlimb of *Nothronychus*. The appendicular elements were CT-scanned to create DICOM images. These data were imported into 3d Slicer to obtain object files of 3d virtual images. The object files are to be moved to OpenSim to analyze locomotion.

The synovial capsule of *Nothronychus* is marked by a smooth surface. Its extent is reduced by soft tissue. Posteriorly, cartilage associated with the antitrochanter is increased from previous models, shown by a rugose surface. An inner acetabular membrane marked by a small anteroposterior ridge prevented medial displacement of the femoral head. Compressive and tensile stress fields cancelled each other out above the acetabulum, resulting in reduced ossification at the supra-acetabular crest and division of pre-acetabular and post-acetabular alae. Development of the pre-acetabular labrum was enhanced by increased compressive stress induced by body weight. An ossified transverse enthesis divided a cartilage pad shown by roughened bone from an enlarged, partially ossified iliofemoral ligament. The femur would have been held nearly horizontally, with abduction increasing with maximal protraction. In contrast to reduced movement at the hip, protraction and retraction at the knee were little constrained. The meniscus would have been thicker laterally than medially within the knee. Therefore, hip and knee were then considered similar to walking in *Numida* and *Struthio*. Range of sagittal motion at the hip of *Nothronychus* was limited to 7-10º, as in *Numida*. Therefore, the femur functioned as little more than a shock-absorber. Knee motion is estimated at 45º.

Reproduced locomotion in *Nothronychus* was strikingly similar to a modern walking bird. Therefore, many associated characters evolved more than once. Hinge joints capture most of the relevant motion, but the enlarged pre-acetabular alae and enlarged abdomen resulted in some abduction with protraction. The current model does not capture movement associated with turning.

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Technical Session 8: Mammal Paleoecology (Thursday, October 19, 2023, 1:45 PM)

**THE INFLUENCE OF THE TERMINAL PLEISTOCENE EXTINCTION ON ECOLOGICAL COMPLEXITY AND PREDATOR PREY INTERACTIONS WITHIN A MAMMAL COMMUNITY**

Smith, Felisa A.[1], Elliott Smith, Emma A.[2], Villasenor, Amelia[3], Tomé, Catalina[4], Lyons, Kate[5], Newsome, Seth[1]

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Modern trophic downgrading is leading to changes in the ecological interactions within communities. For carnivores, in particular, the loss of apex species may have a cascade of effects. Here, we use the fossil record of the terminal Pleistocene to explore the consequences of past trophic downgrading. We characterize both the isotopic and body-size niche of a mammal community in Texas before and after the event to assess the influence on the ecology and ecological interactions of surviving species (>1kg). Pre-extinction, a variety of $C_4$-grazers, $C_3$-browsers, and mixed-feeders existed, similar to modern African savannas, with likely specialization among the apex carnivores (two sabertooth cats) for juvenile grazers. Post-extinction, body size and isotopic niche space were lost, and the $\delta^{13}C$ and $\delta^{15}N$ values of some survivors shifted. We see mesocarnivore release within the Felidae: the jaguar, now an apex carnivore, moved into the specialized isotopic niche previously occupied by extinct cats. Puma, previously absent, became common and lynx shifted towards consuming more $C_4$-based resources. In contrast, we observe little changes in diet or body size among the surviving Canidae. Overall, considerable ecological complexity was lost in the Holocene community. Our results suggest that the impact of trophic downgrading on communities may be taxonomically specific.

**Funding Sources** This research is supported by the National Science Foundation Division of Environmental Biology (DEB 1555525; FA Smith PI; SK Lyons and SD Newsome, co-PIs).

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Technical Session 17: Afrotheria & Mammal Macroevolution (Saturday, October 21, 2023, 8:00 AM)

**A MICROMORPHOLOGICAL PERSPECTIVE ON TAPHONOMY IN THE COMPLEX FOSSIL-BEARING CAVES OF WEST SUMATRA**

Smith, Holly E.[1], Morley, Mike[2], McAdams, Conor[2], Zaim, Jahdi[3], -, Aswan[3], Puspaningrum, Mika[3], Trihascaryo, Agus[3], Price, Gilbert J.[4], Louys, Julien[1]

[1]Griffith University, Durham, Tyne and Wear, United Kingdom, [2]Flinders University, Adelaide, South Australia, Australia, [3]Institut Teknologi Bandung, Bandung, Indonesia, [4]University of Queensland, Brisbane, Queensland, Australia

Lida Ajer and Ngalau Gupin are karstic caves situated in the Padang Highlands, western Sumatra, Indonesia. Lida Ajer, in west Sumatra, is best known for yielding fossil evidence that places the arrival of *Homo sapiens* in Southeast Asia ~20,000 years earlier than previously thought. Ngalau Gupin, in west Sumatra, recently produced the first record of hippopotamid *Hexaprotodon* on the island, representing the only globally extinct taxon in Pleistocene deposits from Sumatra. Microstratigraphic (micromorphological) analyses were applied to unconsolidated fossil-bearing cave sediments from these two sites. We use micromorphology as part of a micro-contextualised taphonomic approach to identify the diagenetic processes affecting fossils and sediments within these caves, throughout their depositional history. The fossil-bearing sediments in Lida Ajer have been subjected to a suite of natural sedimentation processes ranging from water action to carnivore occupation, which would indicate the fossils underwent significant reworking prior to lithification of the deposit. The results demonstrate that the base of the unconsolidated fossil-bearing sediments in Ngalau Gupin were derived from the interior of the cave, where the matrix was partially phosphatized as a result of guano-driven diagenesis, indicating that the deposit underwent significant post-depositional modification. These observations can be used to test hypotheses about the integrity of incorporated vertebrate remains and to aid in local palaeoenvironmental reconstructions. The methods employed in this research have not previously been applied to cave sediments from sites in the Padang Highlands and provide key new insights into the palaeontological and natural history of the western region of Sumatra.

**Funding Sources** This study was funded by Australian Research Council (ARC) Future Fellowship , the Future Fellowship and the Winifred Violet Scott Estate Fund Grant.

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**TUSK MORPHOLOGY AND SEXUAL DIMORPHISM IN THE PACIFIC MASTODON (*MAMMUT PACIFICUS*)**

Smith, Kathlyn M.[1], Stoneburg, Brittney E.[2], Dooley, Alton C.[2], Dooley, Alton C.[2]

[1]Geology and Geography, Georgia Southern University, Savannah, Georgia, United States, [2]Western Science Center, Hemet, California, United States

Two species of *Mammut* inhabited North America during the late Pleistocene: *Mammut pacificus,* from California, Montana, and Idaho, and *Mammut americanum*, with a near-continent wide distribution. The primary goal of this study is to describe tusk morphology and sexual dimorphism in *M. pacificus.* Sexual dimorphism is well established in *M. americanum*, in which males have larger tusks ($I^2$'s) and are larger in body size than females of similar ontogenetic stage, but the character of sexual dimorphism in *M. pacificus* is less well known. Initial observations of tusk morphology have indicated that *M. pacificus* tusks tend to be smaller in length and maximum girth than *M. americanum* tusks from individuals of the same sex and ontogenetic stage.

The Western Science Center (WSC) has a large collection of *M. pacificus* fossils from southern California, USA. The collection includes 13 tusks that have been assessed as male based on maximum tusk circumference (MTC), with MTCs ranging from 47–62 mm. These tusks are smaller in girth and length than those of comparably aged *M. americanum* specimens. For example, the MTC of WSC 8817 (51-59 African Elephant Equivalent Years [AEY]), falls within the range of MTCs for younger *M. americanum* males (34-38 AEY), and the relatively unworn tusk of WSC 18743 (37-41 AEY) is similar in length to tusks of *M. americanum* males in their early 20s.

Only two tusks in the WSC Collections (WSC 3817 and WSC 3795) are identified as probable *M. pacificus* females based on MTC. With values of 26.4 mm and 29.8 mm, respectively, their MTCs are within the range of known values for female *M. americanum* tusks and are about half the size of male *M. pacificus* MTCs. Data will be collected on additional *M. pacificus* tusks from the collections at Rancho La Brea and the San Diego Natural History Museum to increase the number of females in the data set and better characterize female *M. pacificus* tusk morphology. We hypothesize that there are female *M. pacificus* fossils at La Brea due to their reportedly small size (shoulder height: 182-244 cm). The largest WSC male is 1.4X the height of the average La Brea mastodon, so this size difference may be due to sexual dimorphism. If our hypothesis is correct, then the character of body size dimorphism between *M. pacificus* and *M. americanum* is similar, even as male *M. pacificus* exhibits relatively smaller tusks than *M. americanum*.

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Romer Prize Session (Thursday, October 19, 2023, 8:00 AM)

**NEW, INTEGRATED MORPHOMETRIC AND ICHNOLOGICAL DATASETS RESHAPE OUR UNDERSTANDING OF PTEROSAUR TERRESTRIAL ECOLOGY**

Smyth, Robert S.

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Pterosaurs were a principal component of Mesozoic vertebrate ecosystems, but their terrestrial ecology remains poorly understood and much debated. Although studies comparing autopodial morphology and ichnites could reveal much about the behavior of grounded pterosaurs, little systematic research has been done. This study compiled the first comprehensive morphometric dataset (n = 196) for pterosaur autopodia. An extensive dataset of extant amniotes (n = 2,010) formed a comparative framework wherein autopodial morphology is directly related to a broad range of known locomotor ecologies. Clade specific variability of pterosaur autopodial skeletal anatomy is identified for the first time in this study. Extensive photogrammetric documentation of pterosaur tracks has revealed restricted soft tissue covering of the pes and a predominantly arthral foot pad arrangement. This results in footprint morphologies that are strongly influenced by skeletal anatomy and permits the assignment of distinctive track types to specific pterosaur clades. Among tetrapods, the autopodia of pterosaurs show an unexpectedly high degree of disparity, with variation in phalangeal proportions comparable to that found in extant birds and lepidosaurs. Non-pterodactyloids exhibit autopodial proportions indicative of strongly arboreal/scansorial ecologies. This is consistent with the exceptional rarity of non-pterodactyloid tracks, known from only a single Upper Jurassic locality. By contrast, pterodactyloid tracks occur at over 140 localities worldwide spanning the Mid-Jurassic to end Cretaceous, much of this record dominated by the most terrestrially adapted groups: ctenochasmatoids, dsungaripterids and neoazhdarchoids. This pattern correlates closely with pterodactyloid autopodial morphology, which shows increasing terrestrialisation through time. Surprisingly, this transition does not occur as a single event at the base of Pterodactyloidea, but as a recurrent pattern in each of the four principal clades.

The mutually reinforcing signals recovered from morphological and temporal variation in autopodial morphology and tracks support a coherent model of pterosaur evolution that includes the first substantive evidence for a major evolutionary event: a mid-Mesozoic invasion of terrestrial environments by pterodactyloids. This transition had profound implications for pterosaur evolution, facilitating an increase in body mass and a diversification into a broad range of new feeding ecologies.

**Funding Sources** Funded by NERC (Natural Environment Research Council) studentship through the Central England NERC Training Alliance.

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Virtual Posters

**"NUTCRACKER" BITE MECHANICS IN *TYRANNOSAURUS REX* TESTED WITH MULTI-PERMUTATION STRUCTURAL ANALYSES**

Snively, Eric[1], Pennings, Amanda[1], Johnson-Ransom, Evan D.[2], Claxton, Alexander[1]

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Tetrapods process food in complex ways, with loading disparities anteroposteriorly and on working versus balancing sides in uneven bites. *Tyrannosaurus rex,* with high adductor forces and jagged tooth rows, experienced a range of biomechanically challenging feeding scenarios. Finite element analysis (FEA) can test structural capability for such scenarios, but often focuses on limited feeding actions to balance model resolution against computational resources.

To assess multiple bite scenarios for *T. rex*, we apply a variant of FEA that solves volumetric stress-strain relations from high-resolution surface geometry, without the need for an internal volume mesh. We checked the method against traditional FEA with analyses of the lizard *Varanus prasinus*. Multiple loadcase results for *T.* rex enabled tests for optimal (minimum stress) loadings. We hypothesized minimized stress with bites using the middle of the tooth rows in *T. rex*, based on the comparatively large teeth in this location and their likely high frequency of forceful contact with food.

We microCT scanned (MICRO, U. Arkansas) a 3D printed skull model of *T. rex* UWBM 99000 (1.157 m), with conjoined jaw joint surfaces restored with reference to FMNH PR 2081. We segmented the scan data to produce STL surface models. Individual muscle forces were scaled from those previously estimated for another specimen (exBHI 2033) and multiplied by ratios of the specimens' subtemporal fenestra areas. Forces for *V. prasinus* were estimated from volumes and fiber lengths of segmented muscles (Avizo). We applied these forces to our meshless models, with reptile bone properties and bushing-style craniomandibular joint tissues. For *T.*

*rex*, potential constraints were applied at all tooth positions, and analyses run on permutations of bilateral (symmetrical and oblique) and unilateral bites.

For *Varanus prasinus*, von Mises stresses matched closely between meshless-volume analyses and FEA with a high-resolution internal mesh. For *Tyrannosaurus* UWBM 99000, peak stresses were lowest (127 MPa) with bilateral anterior bites (maxilla and dentary teeth M2 and d2) and greatest at bilateral posterior bites at M9-d10 (174 MPa). Surprisingly, peak bite stresses at mid-tooth row (M4-d4, M6-d6) diminished slightly from anterior to posterior. These results, and complex shear at the fused nasals, are consistent with habitual and particularly powerful processing engagement with middle teeth, and classic hypotheses of a "nutcracker" bite for *T. rex*.

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Colbert Poster Prize Session

**SPATIOTEMPORAL DYNAMICS OF QUATERNARY RANGE COLLAPSE OF THE GREAT AUK (*PINGUINUS IMPENNIS*): NEW INSIGHTS FROM THE GULF OF MAINE**

Snyderman, Lucia S.[1], Spiess, Arthur[2], Olson, Olivia L.[1], Turvey, Samuel[3], Mychajliw, Alexis M.[1]

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Seabirds are the most threatened group of living birds, with a legacy of pronounced avian extinctions on islands and coastlines extending through the Holocene and historical periods. One such loss was the Great Auk (Alcidae: *Pinguinus impennis*), a large (~5 kg) flightless bird found across the North Atlantic that is often mistaken for a penguin.
While much research has been conducted on the Great Auk across its eastern range, virtually nothing is known about its western range. Great Auk populations were overexploited earliest in Europe during the Upper Pleistocene, and sightings disappear by 1783 in Sweden, 1800 in Canada, and 1834 in the British Isles, leaving Iceland as the 'last' refuge for a colony with a final sighting in 1844. In this research, we apply a conservation paleobiology lens to reconstruct the spatiotemporal dynamics of range collapse precipitating its extinction on both coasts, with a focus on investigating whether the Gulf of Maine was the last stronghold for the species.

Great Auks are known to have occurred in Maine based on archaeological records and historical sightings. We comprehensively surveyed the literature to compile a dataset of 60 indirect dates from 11 Wabanaki shell middens (archaeological sites), categorized by quality using a standardized ranking scheme. The dates confirm the presence of Great Auk in the Gulf of Maine from 4555 to 131 cal ybp. As the last appearance is likely not the last true individual, we applied a Gaussian-resampled, inverse-weighted McInerny (GRIWM) model to estimate an extinction date of 116 cal ybp, supporting that the Maine population persisted until 1834 CE – well after European arrival and colonization. We augmented this dataset with an additional ten new AMS radiocarbon dates generated directly on Great Auk material.

We then applied paleobiological techniques to further understand the ecological dynamics of extinction for Great Auks in Maine, including standard morphological metrics including femur length and diameter, and compared this data to other populations from the North Atlantic. Stable isotope analysis investigated whether Great Auks were occupying a different dietary niche from other Maine seabirds and the potential impact of depleting food sources such as Atlantic cod (*Gadus morhua*). Our study provides novel information on extinction timing, morphology, and diet of the Maine Great Auk population and contextualizes this narrative within a larger range collapse across the Atlantic.

**Funding Sources** Middlebury College Biology Department provided funding.

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Technical Session 3: Fishes & Amphibians (Wednesday, October 18, 2023, 8:00 AM)

**HIDDEN BIOGEOGRAPHY: THE IMPACT OF CONTINENTAL DRIFT ON THE TEMPORAL AND SPATIAL DISTRIBUTION AND EVOLUTION OF TEMNOSPONDYLS**

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Temnospondyls are a diverse and successful group of early tetrapods that originated during the Mid-Carboniferous Period (~320 Ma). Temnospondyls are thought to be the most likely candidates for the lissamphibian stem, eventually giving rise to salamanders, frogs, and caecilians. Over the course of their evolutionary history temnospondyls had a broad geographic and temporal range and populated every continent from the Carboniferous to present day. As the likely progenitors of Lissamphibia, studying the geographic and temporal distribution of temnospondyls can offer new insights into the geographic context for the origins of modern amphibian groups. Furthermore, modern amphibians are highly sensitive to climate and ecological change, so how did their forebears respond to shifts in climate as continents drifted apart? Currently, our understanding of temnospondyl paleobiogeography stems primarily from qualitative interpretations of their phylogeny, stratigraphic occurrences, and estimations of the continental arrangements through deep time. This leads the biogeographic story to change with the discovery of additional fossil occurrences. Shifting to a framework of testable hypotheses, which could then be tested with biogeographic models, would clarify how temnospondyl lineages are distributed as paleogeography changes.

Here, we analyzed temnospondyl biogeography using both established and novel methods. The first analysis using BioGeoBEARS, though widely used, is suboptimal for studying clades with broad temporal and geographic ranges under the effects of continental drift. Our novel analysis–CANDiELand–accounts for these issues. Using a model of communicating classes, which accounts for changes in geographic connectivity through time, conditioned on a time-calibrated phylogeny, can estimate biogeography under continental drift. While BioGeoBEARS estimates a North American origin and North American ancestral ranges for the basal nodes in temnospondyls, CANDiELand estimates a different pattern. Temnospondyls are estimated to originate in Europe and repeatedly dispersed between Europe and northwestern North America during the Carboniferous and Permian Periods, when the aforementioned continents were positioned around the paleo-equator. The results of the CANDiELand analysis suggest tropical climates and shallow seaways to be a significant contributor to temnospondyl origins.

**Funding Sources** We thank the Harlan Graduate Research Fellowship for providing the funding behind this research project.

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Technical Session 10: Euarchontoglires & Xenarthra (Friday, October 20, 2023, 8:00 AM)

### EVOLUTIONARY INTEGRATION AND THE FOSSIL RECORD: UTILIZING PROXIES FOR SPECIALIZATION TO INFER TRAIT COVARIATION IN GEOMORPHA (ORDER: RODENTIA)

Socki, Francesca[1], Calède, Jonathan J.[2], Fox, David L.[1]

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Morphological integration and modularity quantify patterns of trait covariation and independence and have been applied at multiple taxonomic scales. Deciphering the evolution of specialization requires elucidating patterns of trait covariation, contextualized through phylogeny and the fossil record. Morphological proxies used to infer specialization in fossil taxa often involve multifaceted anatomical regions that could correlate with patterns of integration and modularity. The rodent clade Geomorpha is an ideal study system for quantifying patterns of evolutionary integration, given diverse ecologies and specializations across the two extant families that may be reflected in cranial morphology, as well as a rich fossil record including diverse extinct clades. To establish a framework for testing the relationship between specialization and integration in Geomorpha, our study had three components: 1) Quantifying cranial variation via principal component analysis (PCA) on 3D landmark coordinates across the entire extant clade and then separately for each family; 2) Determining evolutionary integration within and between hypothesized cranial modules via partial least squares analysis (PLS) and covariance ratios; 3) Measuring incisor procumbency, a proxy for fossoriality, across modern and several fossil taxa of Geomorpha and comparing procumbency to cranial shape variation. Our PCA analyses reveal distinct differences in shape space between the two families along the first major axis of variation, and clustering at the subfamily and even genus level within Heteromyidae. Based on eigenvector shape changes along PC1 and 2, we hypothesized the Geomyoidea clade to have 3 modules representing the rostrum, the cranial vault, and the occiput. However, PLS analyses show support for two modules separating the occiput from the rest of the crania across Geomyoidea. Within each family the greatest support is for the three module hypothesis, though degrees of integration within and between these modules vary between families. Geomyids have greater variability in procumbency than heteromyids but more limited cranial variation. Procumbency is not linearly related to cranial variation, but species in both families that overlap in procumbency values do not overlap in cranial variation, and vice versa. The implied decoupling of procumbency and cranial shape can be tested with fossil taxa that may differ from extant species in both procumbency and cranial shape.

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**OSTEOHISTOLOGY OF THE THEROPOD DINOSAUR *CERATOSAURUS***

Sombathy, Riley S.[1], D'Emic, Michael D.[2], O'Connor, Patrick M.[3]

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The theropod dinosaur *Ceratosaurus* is represented by over ten individuals from across the Morrison Formation. Three species have been proposed for the genus: *C. nasicornis, C. magnicornis,* and *C. dentisulcatus*. Most authors only regard the type species, *C. nasicornis*, as valid since many of the proposed autapomorphies for both *C. magnicornis* and *C. dentisulcatus* rely on size criteria, however, no study to date has explicitly tested this single-species hypothesis. Osteohistological data for *Ceratosaurus* long bones and ribs have been reported in the literature but were analyzed at the generic level without detailed consideration of potential interspecies differences. Herein we present a detailed analysis of limb and costal histology and growth models for the three purported species to test the single-species hypothesis. Our sample consists of four specimens assigned to *Ceratosaurus* that ranged from ca. 500 to ca. 1100 kg at death, including the proposed holotypes of both *C. magnicornis* and *C. dentisulcatus*, as well as one of the largest and one of the smallest specimens of *C. nasicornis*. Both limbs and ribs have abundant plexiform and reticular vascularity pervading woven- and parallel-fibered tissue. There are low amounts of secondary remodeling in the limbs, whereas there are high amounts of secondary remodeling in the ribs. Three of the four specimens have cortical growth marks restricted almost exclusively in the outer cortex, whereas the smallest specimen preserves no cortical growth marks. Comparing the fit of various growth models using mixed effects modeling and AICc values finds a best fit for the monomolecular growth model, though data from earlier in ontogeny is needed to firmly establish a growth curve for the taxon. Regardless of its precise growth curve, *Ceratosaurus* was an exceptionally fast-growing non-avian theropod, with a maximum growth rate of several hundred kg/yr. Similarly sized representatives of all three proposed *Ceratosaurus* species preserve external fundamental systems, which indicates that they had achieved somatic maturity. Osteohistology supports the presence of a single species within the genus *Ceratosaurus*.

**Funding Sources** US National Science Foundation (EAR1525915).

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Colbert Poster Prize Session

**A CERATOPSIAN MANDIBLE FROM THE 'MID'-CRETACEOUS OF SOUTH KOREA**

Son, Minyoung[1], Makovicky, Peter[1], Lee, Yuong-Nam[2], Kim, Hyun Joo[3], Paik, In Sung[3], Jung, Seung-Ho[4], Kong, Dal-Yong[5], Lee, Sungjin[2], Yoon, Han Sang[2]

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Ceratopsia is a diverse clade of small- to large-bodied, bipedal to quadrupedal dinosaurs from the Late Jurassic to the end of the Cretaceous. Major transformations in ceratopsian dinosaurs include the development of elaborate cranial ornamentation and complex masticatory apparatus seen in the Late Cretaceous taxa. The 'mid'-Cretaceous was a pivotal time in ceratopsian diversification. Early to 'mid'-Cretaceous divergence of major predominantly Late Cretaceous clades (leptoceratopsids, protoceratopsids, ceratopsoids) is inferred, with tantalizing evidence from Central Asia and North America.

A dinosaur mandible was discovered in 2008 from the Turonian ('mid'-Cretaceous) Goseong Formation of Goseong County, Gyeongsangnam-do of South Korea. It was initially reported as belonging to a "hypsilophodontid" euornithopod in 2009. The partial left mandible comprises the articulated dentary, angular, splenial, and seven erupted teeth. Further examination and phylogenetic analyses recovered the mandible as belonging to a basal neoceratopsian. The new ceratopsian can be diagnosed based on unique features, including a prominent dentary ridge that extends anteriorly from the lateral surangular ridge to the base of the coronoid process (shared with *Mosaiceratops*) and the ventral edge of the angular strongly curved posteroventrally in lateral view (autapomorphy; angled in *Udanoceratops* and *Zhuchengceratops*). Micro-CT scan data revealed up to three generations in a tooth family, with the tooth replacement pattern intermediate between the earlier-diverging *Liaoceratops* and later-diverging *Protoceratops*. While the residual roots contribute to the grinding surface as in *Protoceratops* and unlike in *Liaoceratops*, where extensive resorption of roots occurs, the adjacent tooth crowns are not as tightly packed as in *Protoceratops*. Parsimony-based cladistic analyses using two character matrices for ornithischian and basal ceratopsian interrelationships both recovered the new ceratopsian as a sister taxon to Euceratopsia (Leptoceratopsidae + Protoceratopsidae + Ceratopsoidea). The ceratopsian mandible from Korea adds to the ceratopsian diversity from the 'mid'-Cretaceous and provides information on ceratopsian dental evolution.

**Funding Sources** Basic Science Research Program, NRF Korea (#2022R1I1A2060919) to Y.-N.L.; National Science Foundation award FRES (#1925884) to P.J.M.; Jurassic Foundation grant to M.S.

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Technical Session 11: Archosaurs (Friday, October 20, 2023, 8:00 AM)

**"EARLY BURSTS" OF SPECIATION, NO EFFECT OF BODY SIZE, AND POTENTIALLY CRYPTIC DIVERSIFICATION REVEALED BY BAYESIAN OCCURRENCE-BASED APPROACHES DURING THE TRIASSIC ARCHOSAUROMORPH RADIATION**

Sookias, Roland B.[1], Pradelli, Luciano[2], Ascarrunz, Eduardo[3], Silvestro, Daniele[3], Ezcurra, Martin[2]

[1]Géologie, Université de Liège, Liège, Belgium, [2]Sección Paleontología de Vertebrados CONICET-Museo Argentino de Ciencias Naturales "Bernardino Rivadavia", Buenos Aires, Argentina, [3]University of Fribourg, Fribourg, Switzerland

The Triassic archosauromorph radiation was a spectacular radiation which gave rise to the dinosaurs, crocodile-line taxa, and pterosaurs and ultimately set the stage for Mesozoic and large parts of Cenozoic faunas. The radiation occurred as part of ecosystem recovery following the end Permian extinctions, with archosauromorphs generally considered to have radiated into "vacant" niche space. Phylogenetic estimates have been vital in informing our understanding of diversification rates and the origin and timing of divergence of major groups but remain in many cases uncertain due to reliance on morphological data. Bayesian occurrence-based approaches allow corroboration of these estimates but without need for explicit phylogenies, and thus provide a secondary test of conclusions drawn. Here we analyze species-level quasi-occurrences, with true range usually replaced by chronostratigraphic uncertainty, and body size proxy data for archosauromorphs from the Permian-Jurassic Using PyRate and a similar occurrence-based framework in RevBayes using a fossil birth-death model. We examine timing and trajectory of speciation and extinction for archosauromorpha as a whole and major subclades, and test for an association between body size and diversification, which might be expected to be inverse due to longer generation time in larger animals. We find that diversification peaked in the late Permian and early Triassic, earlier than inferred using phylogenetically based estimates, suggesting cryptic lineage splitting may have occurred. Diversification rate gradually declined thereafter, reaching zero at the end of the Norian. These results are consistent with phylogeny-based estimates and may indicate a diversity-dependent diversification rate. RevBayes analyses indicate minor peaks during the Middle and latest Triassic, followed by a larger decline in the Jurassic, corresponding to expansion of major groups and decline of pseudosuchians respectively. We found no evidence for body size influencing diversification. Our study confirms our understanding of this major evolutionary transition and demonstrates the reliability of Bayesian occurrence-based approaches in understanding diversification dynamics even without true occurrence data.

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Technical Session 13: Fishes - Actinopterygians (Friday, October 20, 2023, 1:45 PM)

**A LATE PENNSYLVANIAN (MISSOURIAN) RAY-FINNED FISH (ACTINOPTERYGII) EVOLVED A MOBILE MAXILLA INDEPENDENTLY OF EXTANT CLADES**

Stack, Jack, Stocker, Michelle R.

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Adaptations in an extant clade that impart greater ecological opportunity may explain extreme species richness relative to extinct counterparts. For instance, the extraordinary species richness of neopterygian ray-finned fishes (Actinopterygii) relative to extinct "paleoniscoid" grade actinopterygians is linked to the mobility of the maxilla. The more mobile neopterygian maxilla likely provided more ecological versatility, and thus more opportunity to diversify, than the typically fused maxilla and cheek of "paleoniscoids". However, the enigmatic bobasatraniiform "paleoniscoids" possessed a maxilla that is not fused to the cheek 50 million years prior to the first recognized neopterygian. We characterize the evolution of maxillary mobility in ray-finned fishes by determining if the Bobasatraniiformes are unrecognized Paleozoic neopterygians, or if they independently evolved a similar upper jaw. Previous phylogenetic analyses of Bobasatraniiformes are limited to younger, more derived members of the group, potentially biasing results towards a neopterygian affinity. To correct this bias, we examined specimens of the oldest bobasatraniid, *Platysomus schultzei*, from the Late Pennsylvanian (Missourian) Kinney Brick Quarry of New Mexico. We integrated *Platysomus schultzei* into an existing phylogenetic matrix of 222 discrete morphological characters with 76 other "paleoniscoids", bobasatraniids, and crown actinopterygians for the first time. Both a maximum parsimony analysis in TNT 1.5 and a Bayesian search with the MkV model in MrBayes 3.7.2a inferred *Platysomus schultzei* within a clade of "paleoniscoids" outside of the actinopterygian crown group. Therefore, the more mobile upper jaw of *Platysomus schultzei* evolved independently of neopterygians. Geologically younger bobasatraniids resolve as either sister to neopterygians (parsimony) or sister to living sturgeon and paddlefish (Bayesian), indicating that "Bobasatraniiformes" is paraphyletic and includes early members of the actinopterygian crown group. The presence of an independently derived mobile maxilla in *Platysomus schultzei* implies that the species richness of neopterygians relative to "paleoniscoids" cannot solely be attributed to distinctions in upper jaw morphology.

**Funding Sources** Ernst Mayr Travel Grant (MCZ); Edward C. Raney Fund (ASIH); Heath Robinson-Roy J. Holden/Aubrey & Eula Orange Scholarships (VT); Graduate Student Research Grant (GSA)

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**A NEW HIGHLY PRODUCTIVE MICROSITE FROM THE HELL CREEK FORMATION, MONTANA (USA)**

Steele, Aaron[1], Fabbri, Matteo[1], Wiemann, Jasmina[1], Bohus, Caleb P.[1], Caroll, Nathan[2], O'Connor, Jingmai[1]

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Due to its proximity to the K-Pg boundary, the Hell Creek Formation remains the world's best-studied locality for fossils from the latest Cretaceous (Maastrichtian). However, a vast majority of information pertaining to this important unit is centered on large, charismatic inhabitants such as *Tyrannosaurus rex* and *Triceratops horridus*. Information regarding small faunas remains limited such that only a single avian taxon has been described. Here we describe a new highly productive vertebrate microsite (hereafter called Tooke's microsite) in the Hell Creek Formation near Ekalaka, Montana, collected in July 2022 and sorted from August 2022-May 2023. Typical of microsites from this formation, the most common fossils in Tooke's microsite are scales from the extinct gar *Lepisosteus occidentalis*. However, Tooke's microsite also shows a highly diverse terrestrial amniote fauna including squamates (snakes and lizards), testudines, crocodilians, and theropod dinosaurs (including birds). The diversity, richness, and possible

articulation of some specimens tentatively suggests these fossils accumulated in an oxbow lake setting. Of particular interest, Tooke's microsite has produced an unusually high concentration of mammalian teeth, representing both multituberculate and therian mammals. Mammalian teeth represent the second most common amniote dental remains recovered, exceeded only by crocodilian teeth. Furthermore, the size diversity of archosaur teeth at this site, including size differences between similar tooth morphotypes, is significant, which is interpreted as indicative of a high density of juvenile archosaurs. Whether this density reflects proximity to a nesting site, an environment where younger animals were more common, or simply an artifact of preservation, is yet to be determined.

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Romer Prize Session (Thursday, October 19, 2023, 8:00 AM)

**UNTANGLING COMPLEX MORPHOLOGICAL EVOLUTION IN THE HYPERDIVERSE PASSERINE BIRD RADIATION**

Steell, Elizabeth

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Passeriformes (passerines) exhibit unparalleled diversity among crown birds, accounting for over 60% of extant bird species. Passerines radiated rapidly into one of the most species-rich and widespread vertebrate groups in Earth history, yet disproportionately few studies have attempted to unravel the early evolutionary history of the group. Furthermore, little is understood about the deep time processes underlying passerine diversification that have contributed to their staggering extant diversity (~6,000 living species). Contributing to this lack of research attention are the absence of a comprehensive characterization of passerine skeletal morphology and pervasive convergent evolution across the passerine skeleton, which continue to impede systematic investigations of the early passerine fossil record. Here, I investigate passerine morphological evolution with a novel anatomical framework of unprecedented scale and implement novel quantitative approaches in order to assess homoplasy in morphological datasets. I present a comprehensive, densely sampled anatomical dataset for two character-rich elements of the passerine appendicular skeleton, the carpometacarpus and tarsometatarsus. My de novo character matrix helps elucidate the phylogenetic position of early passerine fossils that help clarify the temporal and geographic origins of major passerine subclades. Synergistically, my newly developed metric to quantify homoplasy, the Relative Homoplasy Index (RHI), reveals elevated rates of homoplasy in passerines with respect to other bird groups. I show that homoplasy varies between two major passerine clades, the suboscines and oscines, with oscines exhibiting more overall homoplasy than suboscines. Despite this, analyses of character state exhaustion suggest that suboscines are under significant evolutionary constraint, whereas morphological evolution in oscines appears to be subject to more relaxed constraints. Oscines, therefore, exhibit higher rates of morphological innovation in the appendicular skeleton, whereas suboscines tend to explore the same overall morphologies repeatedly. The novel morphological datasets and new quantitative methods presented here provide a foundation not only for future work in interpreting passerine evolutionary history, but also for establishing Passeriformes as a model system in macroevolutionary research targeting the evolutionary origins of hyperdiverse clades.

**Funding Sources** Cambridge Climate, Life and Earth UKRI Doctoral Training Partnership
American Ornithological Society
Society of Systematic Biologists

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**NEW ALLIGATOR (*ALLIGATOR* SP.) FOSSIL FINDINGS DEMONSTRATE A CHANGE IN LIMB MORPHOLOGY OVER THE LAST 18 MILLION YEARS**

Steely, Sierra C.[1], Pirlo, Jeanette[2], Riegler, Mitchell[3], Vinola Lopez, Lazaro[3], Bourque, Jason R.[3], Hulbert, Richard[3], Bloch, Jonathan I.[3]

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The Montbrook Fossil Site (MFS) is a late Miocene (5.6 Ma) terrestrial locality near Williston, Florida. Fossil and sedimentological evidence suggest a freshwater ecosystem in close proximity to the paleoshoreline. Fossils recovered from the MFS include undescribed specimens of what may be a new species of alligator based on significant differences in the cranium compared to that of modern *Alligator mississippiensis*. While previous studies have focused on cranial characteristics, we use measurements of the postcrania to ask how different limb structures in the undescribed alligators from the MFS compared to those of other alligator species over the last 18 million years of Florida.

This study primarily used measurements from fore- and hind-limb bones to compare specimens from the MFS to those of Thomas Farm (18 Ma), Love Bone Bed (9.5-9 Ma), Moss Acres Racetrack (7-6.5 Ma), Withlacoochee River 4A (7-6.5 Ma), Palmetto Fauna of the Bone Valley region (5-4.5 Ma), Haile 7C (2.2-1.9 Ma), Hornsby Springs, and Itchtucknee River Site (50-11 Ka). Five measurements were taken from the humerus, femur, radius, ulna, tibia, fibula, and metatarsals. Each specimen was measured for the total length (TL), the minimum diameter of the diaphysis (MD), TL/MD, distal width, and proximal width using digital calipers. Data for the 650 measured elements were compiled in an Excel spreadsheet. To account for ontogeny, we also generated mean and largest-body-size data for each site, although a preservational bias towards larger individuals appears to exist in most localities. Results from statistical analyses demonstrate that the MFS alligator species is morphologically different compared to alligator species over the last 18 MYA of Florida. Total length for limb elements increased over time and although MD increased over time for all elements, we did not see an increase in minimum diameter in the metatarsals. To account for ontogeny, we also generated mean and largest-body-size data for each site, although a preservational bias towards larger individuals appears to exist in most localities. Overall, the data demonstrates alligator limb size increasing over time with the MFS species demonstrating a more robust body structure compared to modern-day *A. mississippiensis*.

**Funding Sources** iDigBio Summer Program, NSF EAR 1645530, DBI 1756306, DBI1547229, The Felburn Foundation

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Technical Session 11: Archosaurs (Friday, October 20, 2023, 8:00 AM)

**A NEW HYPOTHESIS FOR EARLY DINOSAUR DIVERGENCES INFORMED BY SPECIMENS FROM THE UPPER TRIASSIC (REVUELTIAN: NORIAN) SNYDER QUARRY OF NORTHERN NEW MEXICO, U.S.A.**

Stiegler, Josef[1], Heckert, Andrew B.[2]

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The vertebrate fauna of the Late Triassic Chinle Formation in the Chama Basin of Northern New Mexico is known primarily from several multi-taxon bonebeds. Although each of the Hayden (HQ), Snyder (SQ), Canjilon, and Whitaker (*Coelophysis*, CQ) quarries yields articulated or associated dinosaur skeletons, the theropod *Coelophysis bauri* remains the only named taxon from the Chama Basin succession that can be unequivocally referred to one of the three major clades of dinosaurs. Phylogenetic analyses have recovered other dinosaurs from the HQ (*Tawa hallae*) and CQ (*Daemonosaurus chauliodus* and CM 31368) alternately within Theropoda and outside of Saurischia; this taxonomic uncertainty is exacerbated by the high degree of ontogenetic variability in early dinosaurs. To help clarify these issues, we re-evaluated previously described dinosauromorph fossils from the SQ and CQ via gross morphology and μ-CT and studied several undescribed dinosaur fossils from the most recent SQ excavations (2007–2009).

A large, disarticulated coelophysoid theropod skeleton was collected within a single SQ jacket, and is represented by cervical and sacral vertebrae, the pelvis, and distal hindlimb. Other comparably sized elements identifiable to Coelophysoidea and possibly referable to the same individual are scattered up to 2 m away from the jacket. These include additional vertebrae, a scapulocoracoid, and paired femora. When all theropod material from the SQ is treated as one taxon, the 'SQ theropod' is differentiable from *C. bauri* and occupies an early-diverging position within Coelophysoidea in our phylogenetic analyses.

A second new partial skeleton from the SQ consists of associated hindlimbs—paired femora and a right tibia. The tubera and muscle scars of the proximal femora are similar to the penecontemporaneous taxa *Chindesaurus bryansmalli* and *T. hallae*; however, the proximal condyles of the tibia are separated by only a single notch posteriorly rather than the double notch present in the named taxa. An ilium from the SQ that was previously referred to *Caseosaurus crosbyensis* may belong to the taxon represented by these hindlimbs. Our phylogenetic analyses recover this skeleton outside of Saurischia in a clade including *T. hallae*, *C. bryansmalli*, *D. chauliodus*, CM 31368, and several femora from Petrified Forest National Park. This suggests that non-saurischian dinosaurs were persistent elements of the Chinle Fm. fauna in the latter half of the Norian.

**Funding Sources** This work was supported by NSF 1501489.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**AN ARTICULATED PHYTOSAUR TAIL FROM TEXAS AND SUPPORT FOR ECOLOGICAL DIFFERENTIATION WITHIN THE CLADE**

Stocker, Michelle R., Foffa, Davide, Nesbitt, Sterling J., Iannacone, Geno, Yarborough, Vicki

Geosciences, Virginia Tech, Blacksburg, Virginia, United States

Phytosaurs are Triassic archosauriforms that have been linked to a semi-aquatic paleoecology because of morphological similarities to extant crocodylians. However, the two groups are only distantly related, and a previous concentration on phytosaur cranial anatomy has overlooked and oversimplified our understanding of their postcranial anatomy. Recent work showed variation in sacral anatomy that points to a range in locomotor ability and habitat preference within the clade. This range is exemplified by the well-preserved *Mystriosuchus*, which has been reconstructed as marine because of postcranial features, particularly the anatomy of the caudal vertebrae. However, North American taxa often are preserved as incomplete or disarticulated materials in fluvially deposited sediments with little to no associated postcrania. Here we describe a new specimen from the Dockum Group that includes one of the only North American phytosaur tails. This specimen points not only to differences in postcranial anatomy but also potential underappreciated differences in paleoecology within Phytosauria. The new specimen consists of mostly articulated trunk and caudal vertebrae, dorsal osteoderms, and a femur that were collected from the upper portion of the Cooper Canyon Formation in Garza County, TX. Neurocentral sutures are closed, and these sutures are obliterated in the caudals, indicating that this individual achieved some level of skeletal maturity; additional trunk and cervical vertebrae are needed to further establish the relative age of this individual. The caudal vertebrae have gracile neural spines that are dorsally tall and unexpanded anteroposteriorly, unlike the neural spines of *Mystriosuchus* that are mediolaterally thickened and expanded widely anteroposteriorly. The hemal arches are paddle-like versus the proximally stick-like and distally spatulate hemal arches in *Mystriosuchus*. The few preserved osteoderms are thickened and deeply ornamented in contrast to the smaller and thinner paramedian osteoderms in *Mystriosuchus*. Comparisons of the hindlimbs of the new specimen and *Mystriosuchus* show dramatic differences in femoral length, circumference, and robusticity. These observations follow similar morphological trends observed in thalattosuchians, with differences between this new Texas specimen and the more-similar *Mystriosuchus* and marine thalattosuchians and reveal more complex postcrania and paleoecologies within Phytosauria than previously recognized.

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Technical Session 10: Euarchontoglires & Xenarthra (Friday, October 20, 2023, 8:00 AM)

**DIGGING INTO THE PAST: INFERENCE OF FOSSORIALITY AND DIGGING MODE IN FOSSIL RODENTS USING EXTANT FOSSORS AS A GUIDE**

Strassberg, Sarah S.[1], Angielczyk, Kenneth D.[2]

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Rodentia is an optimal clade for studying convergent evolution of fossoriality and impacts of digging on morphology. Fossoriality has evolved independently in various rodent clades (e.g., mole-rats, gophers, ground squirrels), and vastly different digging modes (scratch, chisel-tooth, head-lift) are observed in extant rodents, sometimes even within the same taxon. It is well noted that general fossorial adaptations are reflected in skeletal morphology, but broad quantitative investigations of traits closely associated with fossorial specialization and digging mode are lacking, particularly in taxa that use multiple digging modes. Various extinct rodents also show evidence of fossoriality, whether by being found in burrows (e.g., *Palaeocastor*) or by exhibiting skeletal traits comparable to modern fossors. However, degree of fossorial specialization and digging mode in extinct rodents remain poorly understood. Creating and validating indices of digging mode using extant species and applying them to fossils may provide a valuable window into rodent fossoriality and behavior in deep time. We collected digging mode data (e.g., from behavioral/kinematic studies) and morphological data related to digging, including dimensions of the ulna, olecranon process, humerus, deltopectoral crest, metacarpals, and terminal phalanges; incisor procumbency angle; occiput height and angle; and nasofrontal suture complexity. Preliminary analysis of 90 crania representing 21 extant species across four families suggests that nasofrontal suture complexity, occiput angle, and procumbency angle are effective metrics for inferring digging mode. Head-lift and chisel-tooth diggers consistently have higher nasofrontal suture complexity and lower occiput angle than scratch diggers and terrestrial taxa (likely a reflection of increased biomechanical stresses on the dorsal skull and/or larger neck/jaw musculature), whereas both single- and multi-mode chisel-tooth diggers tend to have more procumbent incisors than non-chisel-tooth diggers. Morphological data will also be collected for 30 fossil rodent species across 18 families, and phylogenetically informed discriminant function analysis will be used to infer digging mode in these taxa. This project will provide new insights into ecomorphology and behavior in the rodent fossil record and a better understanding of the dynamics of fossoriality in ancient and modern ecosystems.

**Funding Sources** Burke Museum Vertebrate Paleontology Collections Study Grant

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**MORE TROUBLE FOR BIG AL: REPORT OF THE FIRST CRANIOFACIAL LESION IN THE PATHOLOGY-RIDDEN SPECIMEN OF *ALLOSAURUS JIMMADSENI* (DINOSAURIA: THEROPODA) KNOWN AS "BIG AL" (MOR 693)**

Stricklin, Maranda, Rhynard, Peter, Ridgely, Ryan, Witmer, Lawrence M.

Ohio University, Athens, Ohio, United States

The Late Jurassic Morrison Formation theropod *Allosaurus* is among the best known and most studied of all dinosaurs. One specimen in particular—an almost complete subadult skeleton referred to *A. jimmadseni*, known as "Big Al" (MOR 693)—is famous for the large number of pathologies (as many as 19) from throughout the postcranial skeleton. Here we report the first pathology from the skull, a cyst-like lesion in the roof of the mouth. The lesion was studied with gross observation and computed tomographic (CT) scanning. The lesion is a rounded ovoid structure about the size of a walnut with a smooth ventral surface. It is located on the ventral midline surface of the palate near the juncture of the vomer, pterygoid, and palatine bones. The lesion is directly adjacent to the choanae. CT scan data confirm that the lesion is hollow and that the outer shell is bone. Internally, it appears that the lesion is comprised of at least three bony chambers. The lesion contacts the adjacent palatal bones but did not grossly alter their form. A first question is whether the bony swelling is actually a pathology and not simply a pneumatic sinus, as multichambered sinuses are common in theropods; however, there are no pneumatic foramina or obvious sources of diverticula, confirming its pathological status. Hollow bony cysts that form external to definitive bones are uncommon, making differential diagnosis difficult, but there are candidates such as aneurysmal bone cysts. As for etiology, infection and/or inflammation of the palatal mucosa is most likely, although neoplasm cannot be ruled out. There is no sign of major trauma, but minor trauma followed by infection remains possible. The location of the lesion near the juncture of the naso- and oropharynx may be significant in that many amniotes have aggregates of lymphoid tissue ("tonsils") in precisely this region to guard the entrance to the airway and esophagus, enhancing the immune response to pathogens. Although pharyngeal lymphoid tissue tends to be more dispersed within the mucosa than the encapsulated tonsils of humans, pharyngeal "tonsils" have been identified in birds (e.g., ratites) and crocodilians, raising the chances that the lesion in MOR 693 may have something to do with lymphoid tissues. These preliminary findings allow a more refined search of the voluminous veterinary and medical literature to better diagnose this latest entry to the list of Big Al's ailments.

**Funding Sources** US National Science Foundation: NSF IOB-0517257, IOS-1050154, IOS-1456503; Swedish Research Council: SRC 2021-02973; OU Heritage College of Osteopathic Medicine

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Technical Session 15: Paleoecology & Paleoclimatology (Friday, October 20, 2023, 1:45 PM)

**LIGHT STABLE ISOTOPE GEOCHEMISTRY OF UPPER TRIASSIC TO LOWER JURASSIC VERTEBRATES FROM THE ELLIOT FORMATION OF SOUTHERN AFRICA**

Suarez, Celina A.[1], Choiniere, Jonah[2], Bordy, Emese[3], Sharman, Glenn[1], Oberg, Danielle[1], Howard, Benjamin[1]

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The Elliot Formation is one of the few continental rock units that both preserves a rich fossil record and encompasses the end-Triassic extinction (ETE) event, presenting a unique opportunity to investigate how continental extinctions occur and how life recovered from one of the "Big Five" mass extinctions. To help characterize ecosystems before and after the ETE, we analyzed stable C- and O-isotopes of the carbonate molecules within tooth/bone phosphate from the Upper Triassic lower Elliot Formation (lEF) and contrasted them to Lower Jurassic upper Elliot Formation (uEF) taxa. In the lEF, aquatic chigutisaurid enamel has very low $\delta^{13}C$ and $\delta^{18}O$ values, -12.8 ± 0.4‰ and -18.1 ± 0.3‰, respectively (relative to Vienna Peedee Belemnite). Strangely, enamel from the large-bodied cynodont *Scalenodontoides* has similar values, $\delta^{13}C$ = -13.8 ± 0.6‰ and $\delta^{18}O$ = -18.6 ± 0.1‰, while "rauisuchian" enamel has higher averages ($\delta^{13}C$ = -9.5 ± 0.8‰ and $\delta^{18}O$ = -9.2 ± 3.4‰). Similarly low isotopic compositions and standard deviations of *Scalenodontoides* and chigutisaurid teeth suggest aquatic habits for *Scalenodontoides*, a hypothesis made more intriguing by its large body size and superficially similar dental morphology to the extant hippopotamus. This study provides the first geochemical evidence to support this hypothesis. The uEF presents a much more diverse ecosystem to evaluate. *Ceratodus* has C-isotope values that are the most enriched of all taxa sampled (-3.4 ± 0.6‰), typical of an aquatic diet. Resource partitioning is apparent in the three main sauropodomorph taxa. *Pulanesaura,* the largest of the sauropodomorphs, has the most $^{13}C$-enriched isotopic composition (-6.1 ± 0.1‰), while *Massospondylus,* the smallest, has a composition of -8.1 ± 0.1‰. *Aardonyx,* the intermediate-sized sauropodomorph, has the lightest C-isotope value (-9.4 ± 0.4‰). Presumed carnivorous taxa have the lightest O-isotope values ranging between -9.4 to -8.33‰ as opposed to herbivores, whose O-isotopic composition show a maximum O-isotope value recorded by *Pulanesaura* at -6.2 ± 3.1‰. These data suggest consumption of enriched leaf water by herbivores as opposed to depleted river water consumed by carnivores. The expansion of known lEF taxa due to our ongoing excavations will improve the understanding of the post-ETE ecosystem changes. Nonetheless, these data suggest that a complex, well-partitioned ecosystem developed early in the Jurassic of southern Africa soon after the ETE.

**Funding Sources** National Science Foundation (NSF-SGP 1761576)

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Technical Session 11: Archosaurs (Friday, October 20, 2023, 8:00 AM)

**NEW ARCHOSAUROMORPH REPTILES FROM THE UPPER BUNTSANDSTEIN (MIDDLE TRIASSIC: ANISIAN) OF GERMANY: NEW EVIDENCE ON TETRAPOD DIVERSIFICATION IN LAURASIA FOLLOWING THE END-PERMIAN EXTINCTION**

Sues, Hans-Dieter[1], Schoch, Rainer R.[2]

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Following the end-Permian biotic crisis, archosauromorph reptiles rapidly diversified and dispersed across the globe at the beginning of the Triassic Period. To date their fossil record is largely known from South Africa and Russia. In the Central European Basin, Early and early Middle Triassic continental red beds are collectively referred to as the Buntsandstein (“colored sandstone”). Whereas the strata of the Lower Buntsandstein are largely unfossiliferous, those of the Middle and Upper Buntsandstein have yielded abundant tracks and trackways representing a great diversity of tetrapods and, at some localities, skeletal remains of tetrapods. The Anisian-age Röt Formation forms the top of the Upper Buntsandstein and comprises variegated sandstones and mudstones, which typically are purple to red-brown in color and contain a succession of paleosols.

A now abandoned sandstone quarry just south of Rotfelden in the Calw district of Baden-Württemberg (Germany) exposed a 6-to-8-m-thick section within the top of the Röt 4 Subformation. Tetrapod remains have been recovered from several horizons in this section. Here we report on a partial skeleton of an unusual new archosauriform and on a small cluster of juvenile rhynchosaur skeletons. The new archosauriform has subrectangular paramedian osteoderms with well-developed sculpturing and without anterior processes. Its posterior cervical and dorsal vertebrae have greatly expanded 'spine tables.' The premaxilla closely resembles that of *Euparkeria*. The teeth have proportionately small crowns without serrated carinae. The humerus is distinctly shorter than the femur. The femur closely resembles those of *Euparkeria* and *Dorosuchus*.

The cluster of rhynchosaurian skeletons comprises the remains of three juveniles. Unlike the more or less coeval early-diverging rhynchosaurs from South Africa, the Röt rhynchosaur has a maxillary dentition with a labial row of teeth separated by a groove from two distinct lingual rows of teeth. The pterygoid bears small denticles. The growing number of tetrapod taxa from the Upper Buntsandstein suggests that tetrapod assemblages had already recovered to a considerable extent 6-7 million years after the end-Permian extinction. This hypothesis receives additional support from the diverse tetrapod assemblages from the Lower and lower Middle Triassic of Eastern Europe.

**Funding Sources** Smithsonian Institution and Staatliches Museum für Naturkunde Stuttgart

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Virtual Posters

## CRANIAL ANATOMY AND PHYLOGENETIC ANALYSIS OF BASAL IGUANODONTIAN *HIPPODRACO SCUTODENS* WITH HIGH RESOLUTION COMPUTED TOMOGRAPHY

Sullivan, Andrue, Poole, Karen

Basic Sciences, New York Institute of Technology, Jonesboro, Arkansas, United States

The Cedar Mountain Formation of Utah preserves a rich fauna including several genera of iguanodontian dinosaurs. The relationships of these taxa to each other and to contemporaneous taxa from other localities remains unclear. In this study, CT scans of the holotype skull of *Hippodraco scutodens* were examined to better elucidate the cranial morphology of this taxon and improve phylogenetic data of iguanodontians.

The holotype specimen of *Hippodraco scutodens* (UMNH VP 20208) was discovered in the Cedar Mountain Formation of eastern Utah. The specimen, consisting of a partial skull and some postcrania, was situated in the Upper Yellow Cat Member. This locality was originally described as earliest Aptian in age (124 Ma), though more recent analyses suggest an older date for the Yellow Cat Member of Berriasian to Valanginian. The cranial anatomy of *Hippodraco* has thus far only been described from surface analysis, whereas this study identifies and describes the cranial material with high resolution computed tomography. CT scans were segmented manually to create 3D models of each element. These were compared with closely related iguanodontians.

Twelve character states were updated from our previous phylogenetic scoring of *Hippodraco*. The updated character states are: a premaxilla with a blunt caudal end and which does not contact the lacrimal; lacrimal contacts the nasal and forms a simple joint with the maxilla; frontal bones are short and broad, and participate in the border of the supratemporal fenestra; the widest aspects of the frontal bones are posterior to the middle of the orbit; the quadrate notch is present, large, and covered by the quadratojugal; the dentary tooth row is straight in dorsal view; the apex of the coronoid process is not expanded; the surangular does not have a secondary fenestra.

These character states were updated for *Hippodraco* in our working phylogenetic matrix, and a parsimony analysis was conducted using a combination of sectorial search, ratchet, drift, and tree fusing until a minimum tree length was found 500 times. This recovered 218 most parsimonious trees. The strict consensus recovers *Hippodraco* in a polytomy with *Xuwulong*, a clade containing *Jinzhousaurus* and *Bolong*, and a large clade containing *Ouranosaurus*, Iguanodontidae, and Hadrosauroidea. This is a slight loss of resolution from our most recent analyses, pointing to continued problems of character conflict within Iguanodontian phylogeny.

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Technical Session 21: Squamates (Saturday, October 21, 2023, 1:45 PM)

**A SPECIMEN OF THE TAXONOMICALLY PRECARIOUS MONSTERSAURIAN LIZARD *PALAEOSANIWA CANADENSIS* FROM THE UPPER CRETACEOUS WAPITI FORMATION OF NORTHERN ALBERTA, CANADA**

Sullivan, Corwin[1], Hamilton, Samantha M.[2], Paparella, Ilaria[1], Bell, Phil R.[3], Campione, Nicolás[3], Fanti, Federico[4], Larson, Derek W.[5], Sissons, Robin L.[1], Vavrek, Matthew[6], Balsai, Michael J.[7]

[1]Department of Biological Sciences, University of Alberta, Edmonton, Alberta, Canada, [2]Department of Biology, Cape Breton University, Sydney, Nova Scotia, Canada, [3]School of Environmental and Rural Science, University of New England, Armidale, New South Wales, Australia, [4]Dipartimento di Scienze Biologiche, Geologiche e Ambientali, Università di Bologna, Bologna, Italy, [5]Royal BC Museum, Victoria, British Columbia, Canada, [6]Cutbank Palaeontological Consulting, Grande Prairie, Alberta, Canada, [7]Temple University, Philadelphia, Pennsylvania, United States

The lizard species *Palaeosaniwa canadensis* was erected in 1928 for a few large, isolated, distinctive varanid-like vertebrae from the Campanian Belly River Group of southern Alberta, Canada and the Maastrichtian Lance Formation of eastern Montana, USA. Numerous other isolated elements, especially from the Belly River Group, have subsequently been referred to *P. canadensis*. These have included not only vertebrae, but also other bones considered likely to belong to *P. canadensis* because of their size, varanid-like form, and/or distinctness from their counterparts in other varanoids. Recent phylogenetic analyses, however, have generally posited *P. canadensis* not as a varanid but as a member of Monstersauria, a clade including extant *Heloderma* and its close relatives.

A lizard right frontal from the DC Bonebed in the Campanian portion of the Wapiti Formation of northern Alberta, previously classified as Monstersauria indet., is clearly referable to *P. canadensis* based on comparisons to an undescribed partial skeleton from the Campanian Two Medicine Formation of western Montana. The DC frontal resembles that of the Two Medicine specimen in overall shape, in the appearance and general arrangement of the fused mound-like osteoderms, and in the positions of the articular surfaces for the prefrontal and postorbitofrontal. While a vertebra from the Wapiti Formation has previously been referred to cf. *Palaeosaniwa*, the DC frontal represents the first strong evidence that *P. canadensis* is present in the Wapiti Formation, extending the Campanian range of this species to about 62° N palaeolatitude. The DC frontal also reveals anatomical details not evident in the Two Medicine specimen, particularly an elongate, subdued anterior process that would have underlapped the nasal. However, *P. canadensis* is taxonomically precarious, in that the vertebra from the original sample that was chosen as the holotype is distinctive among Varanoidea only in having large zygapophyses and a ventrally grooved centrum. These features occur in the Two Medicine specimen, but if they are determined in the future to exist in more than one Late Cretaceous North American varanoid species, *P. canadensis* will become a nomen dubium. This situation highlights the perils of erecting taxa based on highly incomplete material. Nevertheless, the DC frontal and the Two Medicine specimen appear to represent one monstersaurian species whose range stretched from Montana to northern Alberta in Campanian time.

**Funding Sources** Funded by the Natural Sciences and Engineering Research Council of Canada, and an endowment linked to the Philip J. Currie Professorship at the University of Alberta.

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Technical Session 18: Synapsids (Saturday, October 21, 2023, 8:00 AM)

**A COLLECTION OF JUVENILE SYNAPSID POSTCRANIAL MATERIAL FROM THE EARLY PERMIAN CLEAR FORK FORMATION CRADDOCK RANCH AND ITS BEARING ON OUR UNDERSTANDING OF ASTRAGALUS FORMATION IN BASAL AMNIOTES**

Sumida, Stuart S.[1], Huttenlocker, Adam[2]

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The exposures of the Craddock Ranch, including the famous Craddock bonebed, are amongst the most famous early Permian localities of north-central Texas. Formerly interpreted as “Arroyo Formation”, they are now considered lowest Clear Fork Formation, Leonardian in age. The Craddock Ranch exposures produce a wide array of vertebrate fossils, including fishes, anamniote tetrapods, and a variety of amniotes including the diadectomorph *Diadectes,* the eureptiles *Captorhinus* and *Araeoscelis, the* parareptile *Bolosaurus,* and pelycosaurian-grade synapsids. A small collection of mixed elements from Craddock Ranch includes well preserved postcranial materials of both adults and less well-ossified juveniles. Undistorted juvenile elements include vertebrae with unfused neurocentral sutures, right and left sacral ribs of two distinct size classes, a right proximal femoral head, two tibiae of differing size classes, a right astragalus and calcaneus, a tentatively identified left ulnare, and at least one additional element. The incompletely ossified materials are larger than fully adult examples of *Bolosaurus* or the adult eureptiles found at Craddock Ranch. Thus, they are most parsimoniously interpreted as juvenile synapsids. Known pelycosaurs from the locality include the ophiacodonts *Ophiacodon* and *Varanosaurus, Edaphosaurus*, the caseid *Trichasaurus*, and a suite of sphenacodontids. Well preserved adult material including a right astragalus and a stapes compare favorably with sphenacodontid pelycosaur morphology. The material represents at least two size classes of sphenacodontid juveniles preserved together with adults. Whereas this cannot provide definitive proof of differing age classes associating, it does demonstrate that they lived in close enough proximity to be preserved together. Notably, the astragalus appears to develop from a single ossification center, with no evidence of three or four different centers of ossification as has been proposed for captorhinid eureptiles. A comparison of diadectomorph, synapsid, and eureptilian astragalus structure suggests that a common pattern for the origin of the amniote astragalus may be an oversimplification.

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Preparators' Poster Session (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**PROBLEM-SOLVING FOR PREPARING VERY THIN BONE - A SMALL THEROPOD ILIUM CASE STUDY**

Szafron, Barbara, Davidson, Amy

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Preparing fragile bones can be challenging. Bones such as the ilia of small theropods have a flat blade section that thins to 1 mm on both sides of the median vertical ridge. If preserved, this section is often fragmented and unstable. Preparation methods must be adjusted so that such a thin and delicate bone can be worked on safely.

The specimen used in this study is an ilium of a small theropod from Late Jurassic Morrison Formation of Central Wyoming. The matrix is a flaky, grey, fine-grained mudstone. After opening the field jacket, the specimen was heavily consolidated with Butvar B-76 in acetone. Preparation of the exposed side revealed the ilium's complete but extremely thin and fragile blade. To remove the ilium and prepare the other side, a smaller temporary jacket had to be created to support the specimen during matrix removal properly. This support needed to be strong, sturdy, removable, easy to handle during preparation, and also smooth and solid. Any gaps or cracks would cause the shattering of thin bone when worked against them. Two attempts were made to achieve this: one with a plaster bandage and the second with a thick molding plaster. In both cases, plastic film was used as a separator. The initial results proved to be ineffective as such support. The plastic film separator created wrinkles and gaps on the plaster surface. Thus, our support jacket needed an additional smooth solid layer that the bone could be safely worked on against.

To solve this problem, a thin layer of epoxy putty was added over the plaster jacket, and then the specimen was gently pushed against it to create an impression. 30 g of Apoxie Sculpt was used in the layer ranging from 1 to 5 mm in thickness. A plastic film separator was used between the plaster jacket and the epoxy layer, and between the putty and the specimen. After the putty hardened completely, we were left with a temporary support consisting of a sturdy plaster jacket and a separate, smooth, solid layer of epoxy putty. The specimen fits snugly into the support and may be held like a sandwich with finger pressure as the matrix is removed.

We also used a layer of Japanese Kizuki Paper adhered to the non-working side of the specimen with Butvar B-76 in acetone. This ensured the preservation of broken bone during the preparation, with all the fragments remaining aligned. Depending on the researcher's needs, this Japanese paper could be permanent or temporary, as it is easily removable.

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**ON THE VALIDITY OF *STEGODON LUZONENSIS***

Tablizo, Meyrick U.[1], van den Bergh, Gerrit D.[2], Fernando, Allan Gil S.[1]

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A holotype is a reference for the designation of specimens to a particular species. The accompanying descriptions of the holotype can also aid comparisons in case the holotype is lost. However, such is not the case for the missing holotype of *Stegodon luzonensis*. *Stegodon*, an extinct genus of elephantoid proboscidean, was once widespread across Asia from the Late Miocene to Late Pleistocene.

*Stegodon* fossils have been found across the Philippines (e.g., Mindanao, Panay), with most specimens collected from Luzon Island. Luzon specimens were historically attributed to three *Stegodon* species – *S.* cf. *trigonocephalus*, *S.* cf. *sinensis (= S.* cf. *orientalis*), and *S. luzonensis*. *S. luzonensis* is thought to be smaller than *S. trigonocephalus* and *S. orientalis*. Its holotype was allegedly a right hemimandible with an incomplete articulated dentition missing both ends. It was entombed in a gray-black sand unit, several layers above the tuffaceous bedrock, corresponding to the Pleistocene Diliman Tuff (Guadalupe Formation), excavated in the Manila American Cemetery in Fort McKinley (now Fort Bonifacio), Metro Manila. No detailed morphological description was published aside from the approximated dimensions of the dentition – the width was 5 cm, estimated to be 20 cm long with 13 ridge plates (x13x), if complete, and representing a last lower molar (m3) fragment. Unfortunately, the holotype was reportedly missing, further complicating the issue of what *S. luzonensis* is. Still, this did not hamper the use of the name as it has been cited for the Luzon *Stegodon* and even in local popular media.

As we attempt to clarify the taxonomy of the Luzon *Stegodon*, we inevitably have to assess the validity of the supposed endemic form of *S. luzonensis*. In this poster, we revisited its holotype figures and reviewed its treatment in later studies. Based on the published plates, the holotype was a left hemimandible with a fragmentary dentition. The dentition has six preserved ridges, with at least two more anterior ridges based on the exposed anterior root hook. It is low-crowned (brachydont), with widely spaced ridges containing at least eight conules per ridge. Since the serial position of the dentition is difficult to ascertain, it is also problematic to assess whether it represents a pygmy form or that of a juvenile individual. Given these uncertainties, we dissuade using *Stegodon luzonensis* until the holotype is relocated or a neotype from the same locality is uncovered.

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2019-2022 Jon C. Graff Awardees

**REVISITING THE *STEGODON* OF LUZON, PHILIPPINES – INSIGHTS FROM NEW FOSSIL MATERIAL**

Tablizo, Meyrick U.[1], van den Bergh, Gerrit D.[2], Fernando, Allan Gil S.[1]

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Luzon is the largest island of the Philippines, and it is believed to have remained isolated throughout its geologic history. The discovery of a new human species, *Homo luzonensis*, and the new additions to its vertebrate fossil fauna highlight the renewed interest in paleontological and archaeological research on the island. It has long been known that Luzon, like the rest of insular Southeast Asia, also hosted fossil proboscideans. *Stegodon*, an extinct proboscidean genus, has been reported from three vertebrate fossil localities across Luzon. The *Stegodon* fossil materials from Luzon have been historically attributed to either *S. trigonocephalus*, *S. orientalis,* or the endemic *S. luzonensis*. However, little is known about the age of *Stegodon* fossils and their affinities due to a lack of diagnostic cranial material. Here we report and describe a new fossil skull fragment, and isolated molar, which were recently unearthed by a local villager in Solana, Cagayan Valley of northern Luzon. The new fossils were reportedly collected along the western flank of the Enrile Anticline, considered to correspond with the lower part of the Middle Pleistocene Awidon/Awiden Mesa Formation.

The cranial specimen represents a heavily deformed and fractured skull fragment with a large portion of the frontal, the dextral maxilla, and the premaxilla with the proximal segments of the two tusks in the alveole. A complete but half-worn molar is present in the dextral maxilla. The molar has eight fully developed ridges (plate formula x8x) and is identified as either a last upper premolar (dP4) of a large-sized *Stegodon* or the first upper molar (M1) of a medium-sized *Stegodon* of similar size as the Middle Pleistocene *S. florensis florensis* known from the island of Flores, Indonesia. Some of the specimens, including the deformed skull, are currently stored at the Cagayan Museum and Historical Research Center in Tuguegarao City, Cagayan. The discovery of this specimen provides new insights that could help in clarifying the morphology and phylogenetic affinities of the *Stegodon* of Luzon.

**Funding Sources** This work is supported by the 2022 National Institute of Geological Sciences Research Grant, University of the Philippines Diliman to MUT

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Colbert Poster Prize Session

**MORPHOGENETIC MECHANISMS UNDERLYING THE CRANIAL EVOLUTION OF PSEUDOSUCHIANS: COMPARISONS OF EVOLUTIONARY AND DEVELOPMENTAL CHANGES IN SKULL SHAPE**

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Extant crocodylians possess a unique skull characterized by a dorsoventrally flattened and rostrocaudally elongated snout. Although numerous previous studies dealt with their craniofacial evolution from functional perspectives, a morphogenetic process leading to the acquisition of such characteristics has rarely been explored. It previously has been pointed out that the cranial developmental pattern of extant crocodylians shows some similarities with evolutionary skull trends in the crocodylian lineage, but the hypothesis that heterochronic processes have driven the latter and the timing of its establishment has not been verified. Herein we tested this hypothesis quantitatively and qualitatively in pseudosuchians. Two parameters were measured in an ontogenetic series of *Alligator mississippiensis* and *Crocodylus porosus*, as well as in phylogenetically diverse fossil taxa: (1) the ratio of the rostrum to the skull as a measure of snout elongation and (2) the angle between the lower tip of the lacrimal and the dorsoventral midline as a measure of flatness and rotation of the snout. In the resulting morphospace, a common direction of the extant ontogenetic trajectories was that a younger skull with a short-tall snout was modified into the one possessing a longer and more flattened snout. Although the trajectory of evolutionary changes in Pseudosuchia as a whole, was more complex, those in Crocodyliformes paralleled mostly with crocodylian ontogeny with the directions being either the same or opposite to that of the latter, indicating that their cranial shape change was driven by both peramorphic and paedomorphic processes of heterochrony. Furthermore, CT-scan datasets of the ontogenetic series of crocodylians revealed that the skull bones were rotated and elongated during development, accompanied by similar changes in the associated soft-tissue organs. A similar phenomenon was also confirmed in the evolutionary modification of the skull in extinct crocodyliforms, further emphasizing similarities between these ontogenetic evolutionary processes. Despite the lack of data on early ontogenetic stages in extinct species, these results suggest that a similar morphogenetic process of craniofacial transformation may have constrained the evolutionary changes and diversity of the crocodylian skull and that the timing of establishment of such a constraint may trace back to the origin of Crocodyliformes.

**Funding Sources** JSPS KAKENHI grant no. 22J11553 & Overseas Challenge Program for Young Researchers to ST; NSF IOB-0517257, IOS-1050154, IOS-1456503; SRC 2021-02973 to LMW.

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**AN INTRAMANDIBULAR JOINT IN TROODONTIDS AND ITS FUNCTIONAL IMPLICATIONS**

Takasaki, Ryuji[1], Chiba, Kentaro[2], Ichikawa, Miwa[2], Tanaka, Tomonori[3], Tsogtbaatar, Khishigjav[4], Evans, David[1]

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[3]University of Hyogo, Hyogo, Japan, [4]Mongolian Academy of Sciences, Ulaanbaatar, Mongolia

Acquisition of a large gape size through the kinetic intramandibular system is one of the adaptations for swallowing large food items among Reptilia. One example is modern birds that established flexible mandibles by bone elasticity. Intramandibular kinesis has also been suggested for several non-avian theropods based on the loose dentary-surangular and splenial-prearticular contacts, but the level of mobility has not been rigorously documented. Here we describe intramandibular joints in troodontids, primarily based on the type specimens of *Gobivenator* and *Zanabazar* from the Late Cretaceous of Mongolia. Troodontid mandibles can be distinguished as anterior (dentary and splenial) and posterior units (angular, articular, prearticular, and surangular). Dorsally, a thin plate formed of surangular and prearticular loosely inserts between the dentary and the splenial. Ventrally, the splenial forms an articulation surface slightly concave along the axis anteriorly and becomes slightly convex posteriorly. The articular surface itself is very smooth and it is surrounded by rugose texture, which are osteological correlates of a synovial joint. The articular surface is slightly higher medially than laterally. This surface contacts the anteroventral articular surface of the posterior unit, which is fully formed of the angular. The articular surface of the angular is narrow dorsally, where it is flat to slightly convex, and becomes wider ventrally, where it is slightly concave. The intramandibular structures are completely different from extant birds but closely resemble the splenioangular articulation of the Cretaceous diving bird *Hesperornis*. Troodontid intramandibular flexion was likely passive, as suggested by the quadrate medial condyles being positioned much lower and more posteriorly than lateral condyles. These configurations result in lateral displacements of the anterior ends of the posterior units upon gaping. On the other hand, m. pterygoideus is likely to be the major source of the force upon extension. The kinetic intramandibular joint and the associated wide gape are concordant with the recent studies that suggest troodontids mainly fed on soft or small food items since the system is beneficial in whole-swallowing prey with minimum bone-to-tooth contacts, which is a common strategy among carnivorous birds. The cranial kinesis of troodontids thus sheds light on the underappreciated feeding adaptation in the dinosaur-bird transition.

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Virtual Posters

**A BASAL NEOCERATOPSIA (ORNITHISCHIA: CERATOPSIA) FROM THE LOWER CRETACEOUS OHYAMASHIMO FORMATION (ALBIAN), SOUTHWESTERN JAPAN**

Tanaka, Tomonori[1], Chiba, Kentaro[2], Ikeda, Tadahiro[1], Ryan, Michael J.[3], Kubota, Katsuhiro[4]

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Ceratopsia is an herbivorous dinosaur clade that flourished in the Northern Hemisphere during the Late Jurassic to Late Cretaceous. The fossil record suggests that their initial diversification occurred in Asia, with basal neoceratopsians expanding their geographical range to North America by the late Early Cretaceous (Albian). Although the mid-Cretaceous is crucial for understanding biotic dispersion in ceratopsians, the fossil record of basal neoceratopsians from the upper Lower Cretaceous is notably scarce. Here we report new ceratopsian material from the Miyada locality in the Ohyamashimo Formation (Albian) in Tambasasamaya City, Hyogo, southwestern Japan that includes the disarticulated remains of at least two individuals, including ten cranial (premaxilla, partial maxilla, nasal, lacrimal, frontal, jugal, quadratojugal, quadrate, squamosal, and angular) and two postcranial (coracoid and distal end of the tibia) elements. The material is identified as a basal neoceratopsian based on the presence of the articular surface for the rostrum on the premaxilla and the asymmetrical appearance of the distally positioned, distinct primary ridge on the maxillary teeth. Additionally, the expanded cranial portion of the lacrimal in lateral view is only also seen in *Auroraceratops* and *Yamaceratops*. The Miyada neoceratopsian exhibits two potentially diagnostic features suggesting that it represents a new taxon: the antorbital fossa is remarkably deep with a distinct ridge at the ventral margin of the lacrimal, and the articular surface for the squamosal on the dorsal ramus of the jugal is expanded caudally. Our phylogenetic analysis indicates that the Miyada neoceratopsian is closely related to basal neoceratopsians from the Albian of Asia

(*Auroraceratops* and *Archaeoceratops*) and North America (*Aquilops*). This result supports the hypothesis that the dispersion of Ceratopsia to North America occurred as part of the Early Cretaceous Laurasian interchange event (EKLInE), related to the initial establishment of a Beringian land bridge. Further investigation of the Ohyamashimo fauna that includes a rich diversity of frogs, lizards, turtles, dinosaurs, and mammals will provide additional insights into the EKLInE and its impact on the evolution of terrestrial ecosystems during the mid-Cretaceous.

**Funding Sources** Kinoshita Foundation for Science Research Grant

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

### STRUCTURAL AND EVOLUTIONARY ADAPTATIONS IN THE EYE LENS OF THE FREEZE-TOLERANT NORTH AMERICAN WOOD FROG (*RANA SYLVATICA)*

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Repeated periods of glaciation during the Pleistocene caused shifts in the habitat range of many taxa, and the most recent of these periods has created the environment for contemporary evolution. The North American wood frog (*Rana sylvatica*) is unusual as its overwintering strategy is one of freeze-tolerance. It is considered to be one of the first amphibians to expand its range north after the retreat of glaciers. The wood frog can survive in northern climates because it has the ability to freeze solid during the winter, and then in the spring, thaw and spontaneously reanimate. After thawing, they need to be able to see immediately to both avoid predation and to begin breeding. Thus, their eye lenses must be cold-tolerant to ensure that their vision remains clear. As all known vertebrates share a conserved homology of the composite lens proteins -crystallins- we can use the wood frog as a model to elucidate the structural stability in many diverse taxa. Here we discuss the evolutionary adaptation of the crystallin proteins of the North American wood frog. Using cDNA sequences of crystallin proteins from the wood frog and other organisms we created maximum likelihood phylogenetic trees. Then, we used PAML and TreeSAAP from the IMPACT_S bioinformatic package to identify sites of positive evolutionary selection in the DNA sequences and to examine the biochemical properties of those amino acid residues in order to explicate their impact on cold-adaptivity and structural stability.

**Funding Sources** Miami University

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Technical Session 1: Sauropod & Ornithischian Dinosaurs (Wednesday, October 18, 2023, 8:00 AM)

### ONE OF THESE THINGS IS NOT LIKE THE OTHERS—OR IS IT? VARIATION IN PELVIC GIRDLE AND HINIDLIMB ELEMENTS OF CERATOPSID DINOSAURS

Theurer, Brandon C., Sullivan, Corwin

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Ceratopsid paleontology has generally focused on skull bones, but this focus neglects the vast majority of bones in these animals. Few animal activities involve solely the skull. These other behaviors, such as locomotion, could result in adaptations to postcranial bones based on the animal's specific niche. However, many ceratopsid descriptions that do include pelvic girdle and hindlimb elements refer readers to descriptions of other ceratopsids, suggesting that these pelvic girdle and hindlimb elements have similar or essentially the same morphology. Such widespread similarity between taxa would be surprising given that it would imply little to no variation in the niche of ceratopsids regarding any behaviors that do not involve the skull.

Examining ceratopsid hindlimb elements reveals several differences regarding the morphology of various specimens. Such variation includes the relative size of the peduncles on the ischium, the curvature of the ischium, the ratio of femur length to femur width, the presence and size of a groove on the posterior side of the femur head, the position of the fourth trochanter on the femur, a differing medial extent of the tibia beyond the astragalus, the curvature of the lateral flange on the proximal end of the tibia, and which bone the astragalus fuses to if any. Some versions of each variation tend to group within either chasmosaurines or centrosaurines. For example, most centrosaurines tend to have the medial side of the distal end of the tibia extended only as far as the astragalus. However, when mapping this variation to a phylogenetic tree, much of this variation is visible across specimens of the same taxa, making any taxonomic trends difficult to detect if they are indeed present. For example, only some *Centrosaurus* specimens follow the aforementioned centrosaurine trend for the medial extent of the tibia while in others the tibia extends farther medially than the astragalus. This widespread intraspecific variation may be the result of individual variation, sexual dimorphism, or taphonomic processes. Further investigation is needed to establish the cause of the existing variation. If the variation continues to prove non-taxonomic, it may suggest that ceratopsids did in fact have similar niches regarding behaviors that only include the pelvic girdle and hindlimb.

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Technical Session 18: Synapsids (Saturday, October 21, 2023, 8:00 AM)

**THE RETURN OF GEIKIIDAE (SYNAPSIDA: DICYNODONTIA) TO THE UPPER MADUMABISA MUDSTONE FORMATION (UPPER PERMIAN) OF THE LUANGWA BASIN, ZAMBIA**

Thomas, Henry N.[1], Angielczyk, Kenneth D.[2], Peecook, Brandon R.[1]

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The upper Madumabisa Mudstone Formation is a richly fossiliferous upper Permian rock formation exposed in the Luangwa Basin in Zambia. The upper Madumabisa Mudstone tetrapod community is among the most well-documented upper Permian assemblages known and is highly similar to those in the Karoo Basin of South Africa and the Ruhuhu Basin in Tanzania. Dicynodont fossils have been collected in the Luangwa Basin since the 1920s, but a full understanding of the basin's dicynodonts has only recently come under rigorous research attention. In the last ten years, taxonomic revision of, and additions to, the upper Madumabisa Mudstone dicynodont assemblage has affirmed the presence of a high phylogenetic and taxonomic diversity: more than 15 species are recognized, ranging phylogenetically from pylaecephalids to lystrosaurids. In line with other measures of similarity across the region, many species are either shared with the Karoo and/or Ruhuhu Basins or are congeners with occurrences there. One notable exception has been the absence of the ornamented Geikiidae, which occur in both the Karoo and Ruhuhu Basin; historical reports of *Aulacephalodon* in the Luangwa Basin are likely misidentifications of other large 'cryptodont' taxa.

Over several expeditions between 2009 and 2019, the remains of 14 putative geikiid specimens, including four nearly complete skulls, were recovered from the upper Madumabisa Mudstone. The skulls display well-developed tusks, prominent bosses on the nasals, prefrontals, and squamosals, a depressed pineal foramen, and the transverse nasofrontal ridge diagnostic of Geikiidae. The skulls vary in size but appear to represent multiple ontogenetic stages (ranging from juveniles to large mature adults) of a single taxon. Putative male and female morphs are visible among the largest skulls, differing in development of the tusks and cranial bosses. This taxon most closely resembles the well-known South African geikiid *Aulacephalodon bainii*, and preliminary phylogenetic analyses support this affinity, recovering the Zambian form as the sister taxon of *A. bainii* within Geikiidae. However, the Zambian specimens show some differences from *A. bainii* (e.g., lack of a pineal boss in all individuals), suggesting that it may represent a distinct species. The recognition of geikiids in the Luangwa Basin helps fill in a biogeographic gap in late Permian Africa, and further buttresses the similarity between dicynodont faunas across the continent.

**Funding Sources** Field Museum/IDP Foundation African Partners Program; Grainger Foundation; Idaho State University; National Geographic Society (8571-08; 8962-11); NSF (EAR-1337569; EAR-1337291)

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Education & Outreach Poster Session (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**BIAS IN DOCUMENTARY PORTRAYALS OF PALEONTOLOGY AND PREHISTORIC LIFE**

Thomas, Henry N.[1], Humphries, Denver[2], Dickson, Meig C.[3]

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Media portrayals are highly influential in shaping public perception of nature and science. Documentary programs are particularly important, as their nature gives them a perceived air of credibility. However, such programs are susceptible to biases, intentional or not, that affect public perception of the subject matter. The popularity of dinosaurs, and paleontology generally, has guaranteed heavy representation in documentary programs, but it is uncertain what effect these levels of exposure may have on how the history of life on Earth and the science of paleontology are viewed by the public. Content analysis of paleontology documentaries can provide insight into how the public image of paleontology may be distorted.

We analyzed 147 documentary films and television programs focused on prehistoric life, paleontology, dinosaurs, and related topics. Our dataset includes programs from ten countries and ranges in time from 1956 to 2023, though primarily (94%) from 1990 onward. The data recorded for each documentary includes: main subject of each documentary, major paleontological topics discussed (e.g., feathered dinosaurs, K-Pg extinction, human evolution), geological times and locations portrayed (e.g., Late Jurassic Utah), taxa featured, which aspects of the field of paleontology are portrayed, and the name, perceived gender and ethnicity, and occupation of every person featured or interviewed.

We found statistical evidence for overrepresentation of dinosaurs (*Tyrannosaurus rex* in particular), Late Cretaceous and Pleistocene settings, extinction events, and human evolution compared to other clades, time periods, and topics. The majority of these programs showcase fieldwork (58% of programs) and animated life reconstructions of extinct fauna (60%); analytical components of paleontology are less heavily featured (29%). Featured scientists are overwhelmingly biased towards white men (81% men, 86% white, 71% both), most commonly in professorship positions (58%). These biases in representation are liable to inaccurately skew the public's perception of not only the history of life, but also the people who study it and which aspects of the field are receiving scientific attention. We recommend that producers of documentary programs strive for a more balanced portrayal of diversity in both the subject matter and the people who study it.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**LATE PLEISTOCENE ECOSYSTEM EVOLUTION IN SOUTHEASTERN NORTH AMERICA: A TRANSDISCIPLINARY APPROACH USING MODERN AND FOSSIL AMERICAN ALLIGATOR (*ALLIGATOR MISSISSIPPIENSIS*) ENAMEL ISOTOPES**

Tomcho, Atticus[1], Dickens, Mary[1], Mead, Alfred[2], Mead, Heidi[2], Bennett, George[2], Seminack, Christopher[3], Robb, Frank[4], Patterson, David B.[1]

[1]Biology, University of North Georgia, Dahlonega, Georgia, United States, [2]Biological and Environmental Sciences, Georgia College and State University, Milledgeville, Georgia, United States, [3]Lewis Rogers Institute for Environmental and Spatial Analyses, University of North Georgia, Gainesville, Georgia, United States, [4]Environmental Education Awareness Research Support and Services, Indian River Florida, Florida, United States

Existing research points to utilizing ancient ecosystem functionality as a means of understanding contemporary biological responses to climate change and human population expansion. In this study, we use enamel isotope values ($\delta^{13}C$, $\delta^{18}O$) from modern and fossil American alligators (*Alligator mississippiensis*) from the Clark Quarry Site Complex (CQSC; Brunswick, GA) dating to ~60,000 years ago to better understand the aquatic ecosystems and climatic conditions of coastal landscapes in southeastern North America during the late Pleistocene. In particular, we use these data as a proxy for the position of the CQSC relative to the paleoshoreline during this period, which has been variably hypothesized in the existing literature. Serially sampled $\delta^{13}C$ values from modern alligator enamel collected from five localities spanning marine, brackish and freshwater environments in southeastern North America (N=22 individuals), after correcting for contemporary atmospheric $CO_2$ levels, averaged -11.9‰ (±4.8), while $\delta^{18}O$ values averaged 1.7‰ (±4.3). $\delta^{13}C$ values from serially sampled fossil alligator enamel (N=14; CQSC) averaged 8.3‰ (±1.4), while $\delta^{18}O$ values averaged -2.9‰ (±2.2). These data indicate that CQSC alligator $\delta^{13}C$ values are intermediate between modern alligator samples characteristic of strictly marine or strictly freshwater environments, and CQSC alligator $\delta^{18}O$ values are depleted relative to those from all modern aquatic systems sampled here (freshwater, brackish and marine). These data suggest that 1) the CQSC was part of a brackish system during the late Pleistocene, and 2) southeastern North America was dominated by cooler ambient temperatures during this period. This pattern in temperature is also supported by $\delta^{18}O$ values from CQSC megaherbivores (e.g., *Mammuthus columbi*, *Bison latifrons*). This combination of data indicates that the CQSC ecosystem was markedly different from those that characterize the region today. Sea level estimates for this region during this period suggest that the CQSC was approximately 80 km from the coastline, which is a greater distance than contemporary rivers exhibit brackish influence. As a result, these new data should be used to better understand potential variability in coastline dynamics during this important period in landscape and ecosystem evolution in the region.

**Funding Sources** National Geographic Society (NGS-55573R-19)

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**SCREENWASHING THE MECO: RECOVERING MICROVERTEBRATES FROM THE DUCHESNE RIVER FORMATION, UINTA BASIN, UTAH**

Townsend, K.E. B.[1], Stroik, Laura[2], Miller, Emma[2], Murphey, Paul C.[3], Friscia, Anthony[4], Higgins, Pennilyn[5]

[1]Anatomy, Midwestern University, Glendale, Arizona, United States, [2]Biomedical Sciences, Grand Valley State University, Grand Rapids, Michigan, United States, [3]Vertebrate Paleontology, San Diego Museum of Natural History, San Diego, California, United States, [4]Integrative Biology and Physiology, University of California-Los Angeles, Los Angeles, California, United States, [5]Epoch Isotopes, Williamson, New York, United States

The Uinta Basin, Utah contains both the Uinta and Duchesne River Formations, which represent a stratigraphic sequence spanning ~7.8 million years (45.8-38 Ma) and are the type formations for the Uintan and Duchesnean North American Land Mammal Ages (NALMAs).

The Uinta Basin Project aims to construct a high-resolution stratigraphic section and fossil collection effort to document faunal change over the Uintan-Duchesnean transition, an interval that we have shown records the last Eocene hyperthermal event, the Middle Eocene Climatic Optimum (MECO; 41.5-40 Ma). During the 2022 field season, we spot-sampled mudstone and claystone sediments from 13 localities primarily in the Duchesne River Formation. These localities bracket or are known to record the MECO event. Mammal, reptile, and fish specimens (N=108) were identified from 11 localities. While most specimens were fragments of bones, 38 teeth or tooth fragments were found, including 18 cheek teeth and 11 incisors. Rodent teeth were the most commonly identified, with eight assigned to the genus *Metanoiamys*. Other taxa include *Protadjidaumo* and a possible erinaceomorph or marsupial. We were successful in establishing a productive screenwashing methodology and identifying fossiliferous micro-localities in the Duchesne River Formation and will continue these screenwashing efforts to expand the microfossil collection and better capture the impact of the MECO on this Duchesnean faunal community.

**Funding Sources** NSF-EAR 2011695, NSF-EAR2011677, NSF-EAR 2011685, NSF-EAR 2011698

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Paleontological Management Poster Session (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**PALEONTOLOGICAL INVENTORY AT BRYCE CANYON NATIONAL PARK, UTAH RECOVERS LATE CRETACEOUS VERTEBRATE DIVERSITY AND POTENTIAL FOR RESOURCES MANAGEMENT AND FUTURE RESEARCH**

Tran, Tut

Resources Management Division, Bryce Canyon National Park, Bryce, Utah, United States

Although Bryce Canyon National Park (BRCA) is most famous for its iconic pink hoodoos of the Paleogene Claron Formation, the park preserves a nearly continuous sequence of Cenomanian—Campanian depositional environments. These include the coastal Naturita Formation (~100—96 Ma), the deep marine Tropic Shale (~96—92 Ma), and the mostly terrestrial Straight Cliffs and Wahweap formations (~92—77 Ma). BRCA's immediate neighbors, Grand Staircase-Escalante National Monument and Dixie National Forest, have produced diverse vertebrates from these strata, including new dinosaur taxa. Despite BRCA's proximity to and shared geology with these areas, its fossils have been mostly overlooked by staff and the public. An important exception is intensive survey by Jeffrey

Eaton and several cohorts of students at Weber State University (Ogden, UT). From 1988 to 2013, they recorded nearly 200 sites, mostly in the Straight Cliffs and Wahweap formations. These yielded microfossils of fish, sharks, frogs, lizards, turtles, crocodilians, dinosaurs, and mammals, including the type specimens of the multuberculate *Dakotamys shakespeari,* the scincomorph lizard *Monocnemodon syphakos*, and the sawfishes *Columbusia deblieuxi* and *Texatrygon brycensis*. Despite this work, internal paleontological management efforts remained untouched until construction activities in 2020 triggered emergency salvage of Wahweap fossils by Eaton and other Utah paleontologists. This underscored BRCA's obligation to manage its fossil resources and mitigate natural and anthropogenic threats in accordance with the Paleontological Resources Preservation Act of 2009. In response, BRCA Resources Management staff began a new inventory in 2022. Staff recorded 105 sites in the first year, of which 59 were new. Consistent with the Weber State survey, these sites occur mostly in the Straight Cliffs and Wahweap formations and have potential to yield new micro- and macrovertebrate specimens of previously mentioned taxa. These results present interdisciplinary collaborative opportunities at BRCA and have led to joint protective and educational initiatives between resources management, law enforcement, and interpretive staff. Furthermore, this work highlights the potential for future research on late Cretaceous vertebrates of southern Utah. BRCA staff can facilitate such study and enhance the park's ability to protect and interpret its fossil resources by cultivating partnerships with outside researchers and institutions.

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**SMALL SURVIVORS: PUERCAN METATHERIAN SPECIMENS FROM THE WESTERN INTERIOR**

Trenbeath, Chelsea[1], Eberle, Jaelyn J.[2]

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The Cretaceous-Paleogene (K-Pg) extinction devastated most life in North America. Among vertebrates, studies by others suggest that up to 75% of species went extinct. Metatheria (marsupials and their closest fossil relatives) dominated the mammalian fauna during the latest Cretaceous with at least 25 species, but few crossed the K-Pg boundary. Here, we document four fossils of metatherians, including a new species, from three Puercan localities in Colorado and Wyoming.

An upper molar and a partial dentary were recovered from UCM locality 2011035 in early Puercan strata of the China Butte Member, Fort Union Formation in the Great Divide Basin (GDB), southern Wyoming. We identify the isolated upper molar (UCM 103314) as the herpetotheriid *Thylacodon montanensis* due to its morphology and size. UCM 103314 bears stylar cusps A - D, with a straight ectoflexus and stylar cusp B the widest mesiodistally. There is no ridge connecting the metacone to stylar cusp C, as seen in *T. pusillus,* and UCM 103314 is smaller than upper molars of *T. pusillus*. The partial right dentary (UCM 103091) contains p2 - m3 and is also referred to as *T. montanensis* based upon its size and morphology.

Further south in Colorado's Denver Basin, a left dentary (UCM 48598) from a middle Puercan locality in the Denver Formation at Corral Bluffs falls outside the known size range of documented *Thylacodon* species, and likely represents a new species in the clade Herpetotheriidae. Although the teeth are morphologically similar to *Thylacodon* spp., the molars are approximately 30% larger than those of *T. pusillus,* the larger of the two documented species of *Thylacodon.* In comparison, a second dentary with p3 - m4 (UCM 35070) from the Alexander Locality, considered late early Puercan (or Pu1) in prior studies, was referred to *T. pusillus* by previous studies, but is comparable in size and morphology to the jaw from GDB that we refer to *T. montanensis.*

The fossils from the GDB represent the first occurrence of *T. montanensis* from that basin, despite many eutherians and multituberculates from the same locality. Notably, the presence of a new larger species of herpetotheriid from middle Puercan strata in the Denver Formation increases the known diversity of metatherians at this time. It also suggests that among earliest Paleocene metatherians, body size increased within the first few hundred thousand years after the K-Pg extinction, a pattern noted by others for eutherians in earliest Paleocene time.

**Funding Sources** C. Trenbeath's graduate research is supported by the Museum and Field Studies program at the University of Colorado Boulder.

Technical Session 15: Paleoecology & Paleoclimatology (Friday, October 20, 2023, 1:45 PM)

**TESTING TRIASSIC CLIMATE VARIABILITY AND VERTEBRATE DISTRIBUTION ACROSS SOUTHERN PANGEA DURING THE TRIASSIC WITH COMPARATIVE HISTOLOGICAL ANALYSIS**

Trinidad, Valerie[1], Munyikwa, Darlington[2], Zondo, Michel[3], Broderick, Timothy[4], Nesbitt, Sterling J.[5], Griffin, Christopher[6]

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Climate strongly influenced the distribution of major animal groups that emerged during the Triassic period throughout the supercontinent Pangea. The earliest dinosaurs and their associated faunas (Carnian Stage, Late Triassic, ~230 Ma) are recovered along the same paleolatitudinal climate belt across southern Pangea. Characterizing climatic variability within this climatic belt will help constrain the climatic ranges of the first dinosaurs, before they dispersed worldwide. We described the bone histology of five vertebrate taxa from the Carnian of Zimbabwe, including sauropodomorph and herrerasaurid dinosaurs, a gomphodontosuchine cynodont, a hyperodapedontine rhynchosaur, and a suchian archosaur (potentially, an aetosaur). The dinosaurs exhibit well-vascularized cortical bone and no apparent growth marks, suggestive of continuously growing individuals. The cynodont femur also has a well-vascularized fibrolamellar matrix with anastomosing vascular canals throughout the cortex and a single growth mark, indicating it was experiencing rapid growth. In contrast, the rhynchosaur femur and suchian tibia show moderate to poorly vascular bone matrix, possessing multiple lines of arrested growth (LAG) and an external fundamental system (EFS), suggesting that these specimens are slow-growing mature individuals. Comparing this histology to that of similar assemblages from current-day Brazil, Argentina, and India (which fell along the same paleolatitudinal zone during the Triassic), the central Pangean (i.e., Zimbabwean) dinosaurs exhibit more continuous growth than other dinosaurs along this climatic belt, whereas the Zimbabwean rhynchosaur and suchian exhibit slower growth patterns with more frequent cessation of growth than their South American counterparts. The slower-growing Zimbabwean taxa exhibit characteristics suggestive of a harsher environment (e.g., slower growth, frequent cessation), however, the possible endotherms (i.e., dinosaurs, cynodont) from this same assemblage apparently grew rapidly and continuously throughout the year. This is consistent with an overall harsher but less seasonal climate in Zimbabwe compared to Brazil, Argentina, and India. Our results can be further tested via paleoclimate proxies and will contribute to a better view of Triassic climate across Pangea, providing clarity regarding the ancestral environmental tolerances of early dinosaurs.

Technical Session 1: Sauropod & Ornithischian Dinosaurs (Wednesday, October 18, 2023, 8:00 AM)

**BRINGING UP BABY: ONTOGENETIC TRANSITION AT THE FEMORAL CHONDRO-OSSEOUS JUNCTIONS OF JURASSIC SAUROPODS**

Tsai, Henry P.

Biology, Southern Connecticut State University, Middletown, Connecticut, United States

Epiphyseal cartilage caps, which cover the ends of tetrapod limb bones, are critical appendicular structures that ensure joint mobility, facilitate force transmission, and serve as the site of longitudinal bone growth. Although cartilage is rarely preserved in the fossil record, osteological correlates of their attachment can be identified at the chondro-osseous junction, which permits inference of cartilage structure and putative function. The terminal growth plates of sauropod limb bones are characterized by highly convoluted rugose surface textures, which indicates that a massive layer of epiphyseal cartilage once contributed to large portions of functional joint shape. However, the manner that this unique morphology is achieved during sauropod growth is poorly understood. This study examines the ontogenetic transition of sauropod chondro-osseous junction using growth series from Jurassic sauropods, with an emphasis on the proximal end of the femur.

24 femora of *Diplodocus, Camarasaurus*, and apatosaurines were digitized as three-dimensional surface models, which were used to quantify the extent of growth plate rugosities and femoral head convexity. I then examined the transition of these character states during ontogenetic increases in body size. In all sauropods examined, small-bodied individuals possess overall flatter femoral heads with relatively smooth growth plate surfaces. As body size increases, the growth plate surface develops interconnected pits, before the elaboration of these features culminate in the convoluted rugosities observed in larger individuals. Femoral head convexity increases with body size in all taxa examined but is most extreme in *Camarasaurus*. The ontogenetic increase in growth plate rugosities in sauropods is a stark contrast with the pattern observed in most other tetrapods, in which the growth plate tends to become smoother as the animal ages. Growth plate rugosities could potentially be a solution for sauropods to maintain physical traction between the massive epiphyseal cartilage and the subchondral bone, as well as provide an increased surface area for potential vascular supply between the metaphysis and the epiphyseal cartilage. Results from this study provide additional anatomical characters for identifying divergent joint adaptations and growth strategies across different sauropod clades and expand our understanding of the interplay between cartilaginous tissue and subchondral bone across vertebrates.

**Funding Sources** This research is supported by the Faculty Startup Grant of Southern Connecticut State University.

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Technical Session 2: Early Mammals & Carnivora (Wednesday, October 18, 2023, 8:00 AM)

### SHIFT HAPPENS: BENDING STRENGTH DECREASE DURING THE ERUPTION OF THE PERMANENT SABER IN *SMILODON FATALIS*

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The hunting strategies used by sabertoothed carnivorans such as *Smilodon* are unresolved despite a steady stream of morphometric and biomechanical studies over the past several decades. Much of the debate over sabertooth functional morphology has revolved around killing technique of adult individuals. However, permanent upper canines (sabers) took upwards of 20-30 months to fully erupt, and thus represents a critical transition period during an individual sabertooth's life when saber morphology and thus bending strength would have experienced continual shifts over months to years. I generated an eruption sequence model of a *Smilodon fatalis* adult canine to assess ontogenetic shifts in mediolateral bending (the most likely axis of tooth fracture) strength using 3D printed resin models and finite element simulation. A sequence of 40 mm to 120 mm (3-fold difference) erupted canine crown height models exhibited 5- to 12-fold increase in mediolateral deflection when subjected to identical bending forces. These results are consistently supported by physical bending experiments as well as simulations of both tooth and beam theory models. The dramatic downshift in canine bending strength reflects changes in canine cross-sectional shape at the alveolar margin through the eruption sequence, as well as differences in overall 3D shape of the erupted portion of the canine. The permanent canine became less resistant to mediolateral bending the more it erupted. I hypothesize an ontogenetic shift in canine usage by *Smilodon* by way of decreased intensity in its mechanical use as individuals matured towards full saber eruption. The use and maintenance of the fully grown sabers would have necessitated hunting and feeding behavior that minimized mediolateral bending forces to a larger degree than at any earlier point during their growth.

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Virtual Posters

### THE CAINOCHOERINAE (MAMMALIA, ARTIODACTYLA, SUIDAE) FROM THE BASAL UPPER MIOCENE NAKALI FORMATION, KENYA

Tsubamoto, Takehisa[1], Kunimatsu, Yutaka[2], Nakatsukasa, Masato[3]

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The Cainochoerinae is a fossil subfamily of the Suidae (Mammalia; Artiodactyla) with very small body size. Some researchers include only *Cainochoerus*, which is endemic in *ca*. 6.5–5 Ma of South and East Africa, in the subfamily, while other researchers include *Albanohyus* and even *Kenyasus*. *Cainochoerus* is an extremely small suid and has very simple and peccary-like postcanine teeth. It is interesting to note that the molar morphology of the genus recalls that of cercopithecoid primates, that its lower incisors are likely ever growing, and that its postcranial joint morphology is cursorial-like. *Cainochoerus* is a rare taxon among the African Neogene faunas and its fossil record is very limited. Here, we describe a new specimen of *Cainochoerus* discovered from the basal upper Miocene (*ca*. 10 Ma, Tortonian) Nakali Formation of central Kenya, East Africa. The specimen is right m3 lacking the hypoconulid. It has a width of *ca*. 6 mm, bunodont and relatively simple cusps, small pre-median and median accessory cusps, very weak cristids, and no paraconid. It is almost identical in morphology and size to m3 of *Cainochoerus africanus*, which is the only species of the genus, and is distinguished from m3 of other tiny suoids and cercopithecoid primates. The present finding is the oldest record of the genus, contributing to understanding the phylogeny and origination of the subfamily Cainochoerinae.

**Funding Sources** JSPS KAKENHI Grant Numbers 25257408, 16H02757, and 23H02562 (to M. Nakatsukasa). Bilateral Programs Joint Research Project (JSPS-NACOSTI).

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

### WALKING ON EGGSHELLS - BONE MODIFICATION AND ‘DINOTURBATION’ AT EGG MOUNTAIN, MT USA

Turner, Limerick[1], Austin, Gianna[1], Johnson, Dane D.[2], Hannebaum, Zakaria[1], Varricchio, David J.[1]

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The Campanian Two Medicine Formation boasts numerous fossil-rich localities, notably Egg Mountain, near Choteau, Montana. Discoveries include eggs, clutches, and nesting traces from *Troodon formosus*, dinosaur skeletal material, multituberculate and marsupialiform mammals, a large iguanamorph, as well as an overabundance of invertebrate traces. From 2010 through 2014, several skeletal elements were recovered belonging to a large hadrosaurid. A recently prepared jacket highlights three semi-articulated ribs showing extensive desiccation cracking, loss of outermost cortical bone, and fracturing potentially attributable to trampling marks. In addition, invertebrate burrows and pupae cases have been found on multiple horizons within the field jacket. These indeterminate hadrosaurid ribs come from a horizon of associated hadrosaurid material at Egg Mountain with much of the material sharing the same taphonomic characteristics of the ribs. Low sedimentation rates (>10 cm depositional events) and depositional hiatuses known from this locality suggest prolonged subaerial exposure of skeletal elements subjecting them to desiccation and weathering. These ribs, along with other elements show in-situ depressions and extensive fracturing concentrated in isolated areas, suggesting post-mortem modification attributable to trampling. Given that isolated fragments were still present and in-situ within the field jacket, it is likely that skeletal elements were subaerially exposed for an extended amount of time and weathered, where finally after burial were then trampled and broken within the substrate. Here, Egg Mountain presents a unique opportunity to examine ‘dinoturbation’ in the absence of well-defined tracks and reveals a bias favoring the preservation of subsurface biotic activities, and highlights the importance of these ribs withstanding extensive modification and biases against exposed skeletal elements. While limited sedimentation results in the time-averaging of pupae cases and other invertebrate traces, their presence in conjunction with these ribs reveals the dynamic and active nature of this ecosystem.

**Funding Sources** Montana State University Undergraduate Scholars Program

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Paleontological Management Poster Session (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

### HOW PROTECTING SHARKS CAN LEAD TO FINDING DOLPHINS: GEORGE WASHINGTON BIRTHPLACE NATIONAL MONUMENT AS A CASE STUDY IN DEVELOPING AND IMPLEMENTING PALEONTOLOGICAL RESOURCE MONITORING

Tweet, Justin, Santucci, Vincent

Paleontology Program, National Park Service, Washington, District of Columbia, United States

George Washington Birthplace National Monument (GEWA) is a National Park Service (NPS) unit located in the Northern Neck of Virginia and situated on low bluffs overlooking the Potomac River. This

small park unit, focused primarily on cultural and historical resources, may seem on first glance to be an unlikely candidate for notable paleontological resources. However, the bluffs are composed in large part of the fossiliferous early–middle Miocene-age Calvert Formation, and these bluffs and the adjacent shoreline have long been known by locals and rockhounds as places to find fossil shark teeth and other fossils. Following initial contact in the late 1990s and early 2000s, the NPS Paleontology Program has worked closely with GEWA since 2014 on the dual aims of stemming illegal fossil collecting and monitoring non-renewable paleontological resources in the face of rising river levels, increasing storms, and other effects of climate change. The working relationship is a case study for managing fossil resources facing similar challenges. Fossil theft has declined since the project began, as measured by decreasing bluff vandalism left by fossil removal. The benefits of establishing and maintaining a close relationship with park staff are superbly illustrated by the March 2020 recovery of two specimens of Miocene dolphins at imminent risk of loss to wave erosion or unauthorized collection. Plans are in progress to expand this collaborative work with the help of regional institutions.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**"'TIS BUT A SCRATCH!" SAID THE BLACK KNIGHT; SEVERE FACIAL PATHOLOGIES IN A *TYLOSAURUS* FROM THE OZAN FORMATION (CAMPANIAN) OF NORTHEAST TEXAS**

Tykoski, Ronald S.[1], Polcyn, Michael J.[2]

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Mosasaurs were apex predators in the Western Interior Seaway during Late Cretaceous times, and reports of pathologies in mosasaur fossils are evidence of interactions between these animals that sometimes resulted in injuries. A large *Tylosaurus* specimen (DMNH 2021-03-11, nicknamed "The Black Knight") from the Ozan Formation (lower Taylor Group, Campanian) of Fannin County, Texas has substantial osteological trauma with partial healing to both dentaries and the premaxilla. The anterior end of the right dentary has several rough, raised ridges across the lateral and ventral surfaces that were possibly made by teeth dragging across the bone. The left dentary bears a large (>25 cm) hyperossification in its anterior third, and a displaced fracture with rounded edges on the posterior end of the lateral surface. A deep channel excavates the lateral side of the hyperossification adjacent to the 2nd through 5th tooth positions and leads to the bone interior. Ragged-edged crevices traverse the medial side of the hyperossification from the dorsal margin through the Meckelian groove, and the anterior end of the dentary is misaligned. The damage is consistent with the dentary being broken followed by possible infection and partial healing. The premaxilla bears evidence of extreme trauma. The rostrum and dentigerous portion are missing, removed in life, evidenced by partial healing and a mix of bone textures indicative of remodeling. Additionally, the premaxilla damage severed the anterior medial ethmoid nerves, exposing their large diameter canals on the anterior surface. The diameter of nerves is a proxy for carrying capacity, which suggests this damage would have significantly altered the animal's sensory repertoire. Loss of the rostrum would also negate the ability to employ snout ramming for prey acquisition, a behavior previously hypothesized for *Tylosaurus*. We propose these pathologies resulted from a violent interaction between this individual and another large mosasaur, resulting in bone-deep tooth gouges in the right dentary, breaking of the left dentary, and amputation of the body of the premaxilla. Remarkably, the animal survived the incident long enough for extensive osteological remodeling of the damaged bones before death.

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Technical Session 11: Archosaurs (Friday, October 20, 2023, 8:00 AM)

**ONTOGENETIC NICHE PARTITIONING IN PTEROSAURS – ECOLOGICAL AND EVOLUTIONARY IMPLICATIONS**

Unwin, David M.[1], Bestwick, Jordan[2], Smyth, Robert[3]

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Pterosaurs were a principal component of Mesozoic biotas, yet their ecology and evolutionary history remain poorly understood and much debated. A primary assumption, that ecological diversity is equivalent to taxonomic diversity (1 species = 1 ecomorph) may be invalid. Some pterosaurs (e.g., *Pteranodon longiceps*) seem to exhibit ontogenetic niche partitioning (ONP), wherein a single species includes two (or more) ecomorphs. While ONP has profound implications for pterosaurs it remains under-researched. We investigated this phenomenon by combining a wide range of published data with new morphological comparisons and morphometric data sets that span Pterosauria. Tooth microwear data provides compelling evidence of a dietary shift in *Rhamphorhynchus muensteri*, from invertivory among smaller individuals to piscivory in larger individuals. This observation, consistent with distinct size-related changes in skeletal morphology and proportions, indicates that *R. muensteri* included at least two, possibly more, ecomorphs. Morphological and morphometric patterns comparable to those found in *R. muensteri* and indicative of ONP, are present in 30+ species of pterosaur representing 17 of the 20 or so principal clades. This suggests ONP was pervasive in Pterosauria. ONP is intricately associated with the hyper-precocial flight ability of pterosaurs and apparent lack of any parental care. Critically, it provided a mechanism whereby earlier growth stages were able to avoid direct competition for resources with older growth stages. ONP has important consequences for pterosaur ecology. Reassessment of the pterosaur assemblage from the Upper Jurassic of Germany, currently represented by ~13 species, identified 28 ecomorphs. Applied across Pterosauria, to the 200+ species described to date, this relationship implies the existence of at least 400 ecomorphs, a far greater degree of ecological diversity than previously realized. ONP also has implications for our understanding of evolutionary patterns. While small and medium sized ecomorphs are present in some Cretaceous lagerstätten (e.g., Jehol and Kem Kem assemblages) they are, with some rare exceptions, almost entirely absent from other Cretaceous deposits, most probably due to taphonomic bias. If this is correct, then the size increase in pterosaurs during this period likely reflects a broadening of the size range to include small, medium, large and giant ecomorphs, rather than a shift to just large and giant ecomorphs.

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Virtual Posters

**CANADA'S MOST COMPLETE *MERYCOIDODON* FOSSIL**

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Merycoidodonts are artiodactyls that are around the size of modern sheep. Recent studies place them closely related to camels. Merycoidodontidae are abundant throughout the United States and are found as far south as Mexico. In Canada, only a few tooth fragments from Saskatchewan have been described. A nearly complete skull and jaw, RBCM P123, were collected in 1977 from southeastern British Columbia near Flathead River but were only deposited in the Royal BC Museum collections in 2018. RBCM P123 is the first *Merycoidodon* skull found in Canada and the first *Merycoidodon* material found in the Kishenehn Formation. The mid-Eocene to early Miocene Kishenehn Formation outcrops mostly within the United States, with the northern part extending into British Columbia. Other fossils have been found here, such as various plants and algae, mollusks and fish, insects and other, typically smaller mammals, with most fossils being reported from the United States. RBCM P123 shares similar cranial and dental proportions (tooth size, length of tooth row, and tooth size ratios) with both *Merycoidodon culbertsoni* and *Merycoidodon major.* Measurements of the teeth of RBCM P123 are consistent with *Merycoidodon major,* but the cranial measurements are more similar to *Merycoidodon culbertsoni.* Given the taphonomic deformation of the skull, we consider the dental comparisons more reliable, and suggest *Merycoidodon major* is the more likely identification. *Merycoidodon culbertsoni* cannot be fully ruled out due to the missing auditory bulla in RBCM P123, which is a key distinguishing feature between these two species. RBCM P123 has been used in recent publications to indicate an upper age limit for the Canadian part of the Kishenehn Formation of Orellan (Lower Oligocene, 33.9 to 33.3 Ma). If RBCM P123 represents *Merycoidodon major,* this may shift the upper age of the Canadian Kishenehn Formation exposures to the end of the early Arikareean (30.8 Ma).

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Technical Session 16: Theropods - I (Saturday, October 21, 2023, 8:00 AM)

**MUSCULOSKELETAL CONSTRAINTS ON TOP SPEED OF *TYRANNOSAURUS REX***

**EXPLORED USING 3D PHYSICS SIMULATIONS**

van Bijlert, Pasha A.[1], Bates, Karl T.[2], van Soest, A.J. "Knoek"[3], Schulp, Anne S.[4]

[1]Department of Earth Sciences, Utrecht University, Utrecht, Netherlands, [2]Department of Musculoskeletal and Ageing Science, University of Liverpool, Liverpool, United Kingdom, [3]Department of Human Movement Sciences, Vrije Universiteit Amsterdam, Amsterdam, Netherlands, [4]Naturalis Biodiversity Center, Leiden, Netherlands

Locomotor performance metrics (such as top speed) are an important determinant of an animal's ecological role. Due to their exceedingly large body sizes, non-avian theropods faced unique challenges during locomotion, especially at high speeds. Biomechanical analyses of *Tyrannosaurus rex* have identified several limiting factors on top speed: *T. rex* may have lacked sufficient ankle extensor musculature for fast running, and peak stresses on the skeleton may have been too high to safely achieve running at all. In particular, the latter analysis used physics simulations of a 7-tonne *T. rex* constrained to 2D movements, suggesting that speeds exceeding 5.5 m $s^{-1}$ (a fast walk) would lead to unrealistically high stresses.

We have previously developed a 3D multibody dynamic model of *Tyrannosaurus rex* (based on the adult specimen RGM.792000). We have now used this model to perform simulations of stress-limited maximal speed, using similar muscular assumptions to previous simulation studies. Our heavier (~8 tonne) model experienced lower peak skeletal stresses when it was free to move in 3D. This resulted in a higher top speed (6.5 m $s^{-1}$), a grounded running gait with the metatarsals being the limiting factor. However, previous studies did not distribute muscle mass according to an extant phylogenetic bracket (EPB), and it remains unclear how sensitive the simulations are to (unknown) contractile properties of the muscles. Based on ligament attachments, it has furthermore been suggested that the middle (arcto)metatarsal could shift forward during locomotion, potentially reducing peak stresses.

These uncertainties prompted us to develop and validate a model of an extant running bird (the emu, *Dromaius novaehollandiae*). Without using measured kinematics as an input, our simulations match real emus across a wide range of speeds. Notably, preferred stride lengths varied little despite different assumptions regarding muscularity, but errors in muscle mass distribution had a large effect. When basing muscle mass distributions of *T. rex* on an EPB of crocodilians and birds, ankle extensors comprised 4.4 - 5.5% body mass (per leg), more than double the mass used in previous models. This has a strong effect on the preferred gaits and skeletal loading, and thus potentially on top speeds of *T. rex*. Our approach integrates biomechanical insights from extant taxa with fossilized evidence, enabling us to provide a new perspective on this controversial topic.

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Technical Session 9: Sauropsids (Thursday, October 19, 2023, 1:45 PM)

**A RE-DESCRIPTION OF THE LATE PERMIAN PAREIASAUR *NANOPARIA LUCKHOFFI* (BROOM 1936) FROM THE KAROO BASIN OF SOUTH AFRICA, AND A NEW CONSOLIDATED PAREIASAURIAN PHYLOGENY**

Van den Brandt, Marc J.[1], Cisneros, Juan[2], Abdala, Fernando[1], Boyarinova, Elena[3], Golubev, Valeriy K.[3], Norton, Luke A.[1], Smith, Roger M.[1], Rubidge, Bruce S.[1]

[1]University of the Witwatersrand, Evolutionary Studies Institute, Johannesburg, Gauteng, South Africa, [2]Universidade Federal do Piauí, Museu de Arqueologia e Paleontologia, Teresina, Brazil, [3]Russian Academy of Sciences, Borissiak Paleontological Institute, Moscow, Russian Federation

Pareiasaurs are a diverse group of abundant and successful parareptilian herbivores of the middle and late Permian. A recent comprehensive taxonomic re-evaluation of the basal-most pareiasaurs, the Bradysauria, which are restricted to the middle Permian (Guadalupian) of South Africa, recognized this group as a monophyletic clade for the first time, comprising three valid taxa: *Bradysaurus baini*, *Embrithosaurus schwarzi* and *Nochelesaurus alexanderi*, and clarified their stratigraphic ranges. Compared to the South African middle Permian taxa, our current morphological understanding, phylogenetic relationships, and biostratigraphic ranges of the seven South African late Permian pareiasaurian taxa are lacking, and our research now focuses on this group, which account for almost one third of global pareiasaur species diversity.

Based on new preparation of the holotype, we present the first detailed cranial description of *Nanoparia*

*luckhoffi*. We find *N. luckhoffi* valid with several autapomorphies including: small supernumerary bone on the posterior margin of the cheek between the squamosal and quadratojugal; a pyramidal-shaped parietal; tiny foramen on the palatal flange of the premaxilla; a short notch on the margin of the anterior vomer; a ventrally extending flange along the lateral margin of the internal tabulars; and tabulars that extend further than the posterior edge of the supratemporals. Diagnostic features shared with some other pareiasaurs include: distinct, relatively straight and long regular radial ridges surrounding central bosses on most cranial elements; a quadratojugal that reaches or nearly reaches the level of the anterior border of the orbit; and an anterolaterally elongated bilobed central boss on the parietal. Evidence supporting a juvenile ontogenetic stage for the holotype skull, include: unossified cranial sutures; an unossified dorsal braincase; short snout; and fewer marginal teeth than most pareiasaurs. Our updated phylogeny retains *Nanoparia* as a constituent member of the Pumiliopareiasauria, sister taxon to *Provelosaurus* from Brazil.

Using new preparation and some of the first micro-CT scans of pareiasaur material, our ongoing research focuses on *Anthodon*, *Pumiliopareia* and *Pareiasaurus*. We are assessing body mass changes in Pareiasauria over time, the use of osteoderm morphology for species-level systematics of Russian and South African pareiasaurs and updating the biostratigraphic ranges of the different species.

**Funding Sources** GENUS (DSI-NRF Centre of Excellence in Palaeosciences, UID 86073)
Russian Science Foundation No. 23-27-00311, https://rscf.ru/project/23-27-00311/

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

## THE PELVIC GIRDLE IN *MILLEROSTEUS MINOR* AND OTHER DEVONIAN ARTHRODIRAN PLACODERMS

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The pelvic girdle, a structure found in most extant vertebrates, supports the pelvic fin or hind limb. Pelvic girdles evolved in the jawed vertebrates, first appearing, phylogenetically, in antiarch placoderms from the early Devonian. The differing shapes and sizes of the pelvic girdle can provide information as to the locomotion, ecology and lifestyle of different vertebrate species. In fish, the pelvic girdle is associated with and supports the pelvic fin through muscle attachment. In most placoderms, the pelvic girdle, supporting the pelvic fin, was comprised of at least two fin radials which articulated to discrete surfaces on the girdle. Additionally, foramina were present, through which passed nerves and blood vessels associated with the musculature of the fin. In different groups of placoderm fish, such as Antiarchi and Ptyctodontia, pelvic girdles are composed of both dermal and perichondral bone. However, there is variation in Arthrodira – in at least some species, the girdle is made up of perichondral bone deposited around cartilage and in others, such as *Coccosteus cuspidatus*, the girdle is composed of both endochondral and perichondral bone. The pelvic girdles in the placoderm order Arthrodira differ in terms of their shape, size, articular surfaces and the number and position of their foramina – such differences do not necessarily relate to differences in feeding ecology or lifestyle, based on what is currently known about these different species of arthrodires, including those from freshwater (*Millerosteus*, *Coccosteus*) or reefal environments (*Compagopiscis*). It is known from at least some extant fishes that each section of the pelvic girdle can correlate with the specificities and/or intricacies of certain types of locomotion, with some forms of locomotion being more suitable for different ecologies and lifestyles. A better understanding of these differences can inform our understanding of the physiology and ecology of different arthrodiran placoderm species.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

## RE-EXAMINATION OF *VARANUS RUSINGENSIS* (SQUAMATA: VARANIDAE) FROM THE MIOCENE OF KENYA: IMPLICATIONS FOR THE EVOLUTIONARY HISTORY OF *VARANUS* IN AFRICA

Varnham, Grace[1], Kyalo Manthi, Fredrick[2], Head, Jason J.[1]

[1]Zoology, University of Cambridge, Cambridge, United Kingdom, [2]National Museums of Kenya, Nairobi, Kenya

*Varanus* (Squamata: Varanidae) is a cosmopolitan genus distributed across the palaeotropics and Australia, with a fossil record extending into the Paleogene of Africa and Asia. Phylogenetic interrelationships of the extant clades are well resolved, with an African clade that is a sister taxon to the rest of the clade. However, divergence timings and past species richness are poorly constrained due to the limited study of the fossil record which consists primarily of isolated vertebrae that lack species-level diagnostic characters. Past diversity of crown group *Varanus* is limited to only four valid species based on partial skeletons: *V. rusingensis* from the Miocene of Africa, *V. mokrensis* and *V. marathonensis* from the Miocene of Europe, and *V. priscus* from the Pleistocene of Australia.

To reconstruct the evolutionary history of *Varanus* in Africa, we examined cranial elements assigned to *V. rusingensis* from the early Miocene Kiahera Formation of Rusinga Island, Kenya, in order to elucidate systematic relationships and species richness. We compared cranial elements to growth series in extant *V. niloticus* and *V. exanthematicus* to determine if variation between fossil specimens could represent ontogenetic or species-level differences. Our results indicate that at least three specimens do not possess the diagnostic characters of *V. rusingensis*, nor do they represent a different ontogenetic stage of the species. This suggests that Neogene diversity of African monitor lizards may be higher than previously thought, and that durophagous dentition amongst monitor lizards may have evolved earlier than previously recognized.

The results raise questions about what ecological factors are behind the reduced diversity of monitor lizards in present-day Africa; greater past species richness amongst African *Varanus* may correspond to warmer equatorial climates and greater habitat heterogeneity during the early Miocene.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

## CRANIAL MORPHOLOGY AND PHYLOGENETIC RELATIONSHIPS OF AMYNODONTIDAE SCOTT & OSBORN, 1883 (PERISSODACTYLA, RHINOCEROTOIDEA)

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Amynodontidae are an extinct family of Rhinocerotoidea (Perissodactyla) known from the middle Eocene to the latest Oligocene of Asia, North America, and Europe. We describe here two specimens of Amynodontidae, a skull and a mandible of *Zaisanamynodon borisovi* Belyaeva, 1971 from the late Eocene of the Zaysan Basin (Kazakhstan) and a skull of *Metamynodon planifrons* from the early Oligocene of the Big Badlands (United States). They have been incorporated into a morpho-anatomical character matrix and a cladistic analysis including 31 rhinocerotoid taxa. The new phylogeny allows to discuss the relationships of the referred specimens within Amynodontidae and those of Amynodontidae within Rhinocerotoidea. Our cladistic analysis supports the monophyly of the genus *Zaisanamynodon* and clarifies the generic and specific composition of the tribes Metamynodontini and Cadurcodontini. The dichotomy between these two tribes is notably expressed by the presence of several cranial features such as “the deep nasal notch” or “the well-developed preorbital fossa” in Cadurcodontini. These cranial specializations attest to an adaptation of the peri-nasal region to the presence of a proboscis with a feeding function. Our study also opens a discussion on the biogeography of Amynodontidae, their emergence and dispersal in Asia and their subsequent migration to North America, and Eastern Europe. Their presence in Western Europe remains restricted to the Oligocene, after a dispersal related to the “Grande Coupure” event.

**Funding Sources** This project was financially supported by the Swiss National Science Foundation (SNF projects 200021_162359 and P2FRP2_199605).

study concludes that enamel microstructure is less useful for taxonomic identification than previously thought, especially for lower-level taxonomic comparisons among archosaurs that share relatively thin, simple enamel. Enamel microstructure is likely linked to tooth function and placement in the mouth of an organism and less-so to evolutionary history.

**Funding Sources** NSERC RGPIN-2021-03756 to KB

Technical Session 19: Theropods - II (Saturday, October 21, 2023, 1:45 PM)

**EVALUATING HETERODONTY USING THE ENAMEL MICROSTRUCTURES OF SMALL THEROPOD DINOSAURS**

Verstraete, Ashley[1], Larson, Derek W.[2], Evans, David[3], Brink, Kirstin[1]
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The theropod dinosaurs known from the Cretaceous Dinosaur Park Formation (DPF), Alberta, include several taxa erected based solely on isolated teeth. With the recent discovery of articulated specimens of *Saurornitholestes langstoni* preserving the tooth taxon *Zapsalis abradens*, it is possible that other "tooth taxa" are also part of the heterodont dentitions of small dinosaurs and not individual species or may even belong to other archosaur groups. Therefore, our understanding of archosaur diversity in the DPF might be artificially inflating the number of theropod taxa. Previous studies of enamel microstructures in dinosaurs have shown species-specific traits that may be useful for taxonomic identifications. In this study, we examined the enamel microstructure of eight small theropod tooth morphotypes that have previously been regarded as being separate species from the DPF to determine the distribution of enamel microstructure characters, including both morphotypes of *S. langstoni*. We also examined the enamel microstructure of two pterosaur species from the Cretaceous Kem Kem beds of Morocco for a comparison to the small theropods. These data allowed us to determine which enamel microstructure characters are useful for determining shared ancestry, or if enamel microstructure depends more on tooth shape and thus is determined by tooth function. We sectioned the teeth in transverse and longitudinal planes and examined the microstructures with a scanning electron microscope. Results show no major taxonomically informative patterns in enamel microstructure among the theropods and pterosaurs examined here. The theropods in this study all had parallel enamel with basal unit layers, and many with incremental lines. The heterodont teeth of *Saurornitholestes* show differences in the positioning of incremental lines, crystallite sizes, and the presence of tubules, suggesting enamel microstructure is reflective of tooth shape and function based on its position in the mouth. This

Technical Session 1: Sauropod & Ornithischian Dinosaurs (Wednesday, October 18, 2023, 8:00 AM)

**TEMPORAL SEQUENCE AND DIVERSITY OF SAUROPOD DINOSAURS IN THE MIDDLE TO LATE JURASSIC IRHAZER SERIES OF NIGER**

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Field expeditions to the expansive Irhazer Plain southwest of Agadez in Niger have uncovered abundant fossil remains of sauropod dinosaurs from three distinct levels within the predominantly shale and overbank deposits composing the Irhazer Series. The lowest levels include the type locality of the basal eusauropod *Spinophorosaurus nigerensis*. Multiple specimens referable to this species were found in this lower horizon, including an articulated skeleton with portions of the skull. Horizons still in the lower portion of the sequence preserve sauropod trackways of high fidelity characterized by a hind foot with four unguals. Middle horizons of the Irhazer Series are dominated by a new basal eusauropod known from a skull and multiple articulated postcranial skeletons. This taxon, one of the most completely known African sauropods, has stocky proportions. It has a robustly proportioned skull, a neck shorter than its dorsal vertebrae series, and stout appendicular bones. The skull has a particularly large external naris and relatively round supratemporal fenestrae. The teeth, which number up to 18 in the maxilla, have heart-shaped crowns with denticles present only in posterior crowns. The cervical centra are short, and all cervicodorsal vertebrae have fossae on their centra. Anterior chevrons are long and stoutly proportioned with a posterior bulge. The tibia and fibula have cnemial and fibular crests, respectively, running along one-third of the length of their shafts. In upper horizons designated as the Tiouraren Formation, *Jobaria tiguidensis* is the dominant, but not the only, eusauropod present. A second taxon differs from *Jobaria* in having a medially deflected humeral head and longer ulna and radius relative to the humerus, and a putative third taxon has posterior dorsal vertebrae with pleurocoels and a longer humerus relative to the femur. Both taxa are known from partial articulated skeletons in close proximity to remains of *Jobaria* and presumably were contemporaries. The age of Irhazer Series horizons remains controversial. Discovery of an ash bed and other potentially datable beds near fossil bearing horizons opens the possibility that the Irhazer Plain may eventually generate a temporally calibrated series of sauropod-dominated faunas during the Jurassic in Africa.

**Funding Sources** DV is a Marie Sklodowska-Curie Global Action fellow (HORIZON-MSCA-2021-PF grant; Project Ref. 101068861 — EvoSaurAf)

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

## A NEW *SOLENODON* AND HUTIA FROM THE LATE QUATERNARY OF HISPANIOLA

Viñola-López, Lazaro W.[1], Almonte, Juan[2], Luthra, Alisa[1], Bloch, Jonathan I.[3]

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Analysis of largely unstudied fossil collections recovered from caves and sinkholes from western Hispaniola has resulted in recognition of a new capromyine rodent (*Zagoutomys woodsi*, gen. et sp. nov.) and a new solenodontid eulipotyphlan (*Solenodon ottenwalderi* sp. nov.). Fossils of *Z. woodsi* show that it differs from other capromyine rodents in having a mandible with a relatively thin and elongated symphysis, long diastema between the lower incisor and P4, more procumbent incisor, and more anteriorly positioned masseteric crest. While fossils here referred to *Z. woodsi* are rare (n=18) among the thousands of rodent specimens recovered from the study sites, their geographic distribution suggests it was widespread across western Hispaniola. In contrast, fossils of *S. ottenwalderi* are relatively abundant in several localities but restricted to the western portion of the Tiburon Peninsula, like other regionally endemic extinct taxa including the platyrrhine primate *Insulacebus toussaintiana* and the capromyine rodent *Rhizoplagiodontia lemkei*. Fossils of *S. ottenwalderi* show that it was notably smaller than other species of *Solenodon*, reducing the body size gap between this genus and *Nesophontes*. Our phylogenetic analysis recovered the new rodent as sister of *Plagiodontia* which includes the living *P. aedium* and two extinct species. Whereas *S. ottenwalderi* was recovered as sister to the extinct species *S. marcanoi.* and formed along with *S. paradoxus* a monophyletic clade endemic to Hispaniola. Morphological and body size differences of these two new mammals with respect to their sister taxa might suggest niche differentiation with segregation of available resources in these past island ecosystems.

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Technical Session 17: Afrotheria & Mammal Macroevolution (Saturday, October 21, 2023, 8:00 AM)

## MAMMALIAN MOLAR SIZE CAN CHANGE SIGNIFICANTLY WITHOUT EVOLVING: IMPLICATIONS OF LAB NUTRITION STUDIES FOR INTERPRETING THE FOSSIL RECORD

Vitek, Natasha S.[1], Saks, Ella[1], Dong, Amy[1], Ward, Devin L.[2], Pomeroy, Emma[3], Martin-Gronert, Malgorzata[4], Ozanne, Susan E.[4]

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Change in mammalian molar size in the fossil record is usually assumed to be the product of inherited evolutionary change. This assumption is based on two lines of evidence. First, molar size is highly heritable in modern samples of living mammals. Second, molar size is determined over a limited period of development and then fixed for the remainder of an individual's life. However, some proportion of variation in molar size in all

populations cannot be explained by heritable variation. This component of variance leaves open the possibility that environmental factors, especially those experienced during critical periods of development, could cause phenotypically non-heritable, non-evolved, plastic changes in molar size following sub-optimal exposures during a brief window of development.

To test this possibility we analyzed molar sizes in rats that experienced early life nutritional manipulation. Mothers and offspring in an experimental group were fed a significantly lower protein content diet than a control group during embryonic development and suckling until weaning, which is the same developmental period in which molar size is determined. At three months of age, rats were culled and µCT scanned. We measured the length and width of each molar from processed scan data. We hypothesized that reduced nutrition would decrease molar size. Furthermore, we expected that the iterative, cascading process of tooth development would result in the accumulation of greater effects in later-forming teeth. Finally, based on prior research about different patterning mechanisms, we hypothesized that length might respond differently than width. All three hypotheses were supported by results. These patterns indicate that phenotypically plastic changes may be preserved in the fossil record, contrary to common assumption. Future work should explore potential reinterpretations of anagenetic patterns of molar size changes in mammals, especially in those records with fine temporal resolution.

**Funding Sources** Henry Sidgwick Research Fellowship from Newnham College, Cambridge

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Technical Session 18: Synapsids (Saturday, October 21, 2023, 8:00 AM)

## FINDING FOSSILS IN ANT MOUNDS: A LOWER PERMIAN VERTEBRATE MICROSITE WITHIN THE CRADDOCK BONE BED

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[1]Whiteside Museum of Natural History, Seymour, Texas, United States, [2]Museum of The Rockies, Bozeman, Montana, United States

A newly discovered vertebrate microsite formed by the harvesting of fossils by Texas Red Harvester ants offers a glimpse into the lower-Permian micro-vertebrate assemblages of the Craddock Bone Bed (CBB) of Seymour, Texas. Located in north central Texas, the famous CBB contains one of the best preserved Lower Permian vertebrate fossil assemblages in the world. *Dimetrodon* and *Diplocaulus* are a few of its most iconic taxa. A particular outcrop nicknamed the ‘spoil pile’ was originally quarried by Charles Sternberg following the CBB’s discovery in 1907. In the latter half of the 19th century, paleontologists were mostly focused on collecting large eye-catching specimens to bolster their museums and institutions. This meant largely ignoring or digging through important smaller specimens. Today, paleontologists emphasize the importance of collecting as many samples as possible to create clear interpretations of paleo ecosystems. Within the Sternberg quarry hill sits an anthill teeming with fossils. It is our objective to collect, quantitatively evaluate, and describe the fossil assemblage found within matrix of the ant mound. Over the course of 2023, the new microsite has yielded numerous described and undescribed vertebrate taxa including fragmentary bones of *Dimetrodon*, *Diplocaulus*, *Seymouria*, reptiles, amphibians, sharks, and fish.
This study will focus on three key data sets collected from February 2023 to April 2023. These specimens were collected by bulk sampling matrix off the surface of the ant mound to be sorted under magnification. Samples were weighed and then identified using a ‘Leica wild M3Z’ with 6.5x to 40x magnification. Preliminary analysis of the microfossils shows a largely unbiased sampling of the vertebrate fauna of the surrounding lower permian ecosystem. In total just over 1800 fossils were discovered. It has long been speculated that a single genus of freshwater shark and multiple palaeonisciform fish dominated the bodies of water providing a convenient source of food for larger predators like *Dimetrodon*. In total 204 *Orthacanthus* teeth were identified, 305 pieces of shark cartilage were discovered and 99 palaeonisciform fish scales were identified; these large quantities further prove their abundance throughout the ecosystem. Microsites house treasure troves of information, new taxa and discoveries that are critical to our knowledge of vertebrate paleontology.

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**EUDROMAEOSAURIAN FRONTALS POTENTIALLY REFERRABLE TO *ATROCIRAPTOR MARSHALLI* (DROMAEOSAURIDAE: SAURORNITHOLESTINAE) FROM THE UPPER CRETACEOUS (UPPERMOST CAMPANIAN-MAASTRICHTIAN) HORSESHOE CANYON FORMATION OF ALBERTA, CANADA SUGGEST A PREDATOR WITH A ROBUST SKULL**

Voris, Jared T.[1], Zelenitsky, Darla K.[1], Therrien, François[2], Powers, Mark J.[3], Currie, Philip J.[3]

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Dromaeosaurids are poorly known from the uppermost Campanian-Maastrichtian Horseshoe Canyon Formation (HSC Fm) of Alberta, Canada with diagnostic specimens limited to isolated teeth and tooth-bearing elements of the saurornitholestine *Atrociraptor marshalli*. The recent discovery of two isolated eudromaeosaurian frontals from this formation provides new information on the anatomy of dromaeosaurids from this rock unit. The two frontals are similar in size and characterized by wide postorbital processes, large and horizontal supratemporal fossae, and elevated orbital rims. Both frontals are similar to those of the slightly older, upper Campanian saurornitholestine *Saurornitholestes langstoni* from the Dinosaur Park and upper Oldman formations of Alberta and Two Medicine Formation of Montana, in sharing a short nasal contact, a lacrimal contact that is ventrally supported by a thin bony lamina, and a sinusoidal anterior margin of the supratemporal fossa, although the HSC Fm frontals are significantly wider and more robust. Phylogenetic analyses recover both HSC Fm frontals within Saurornitholestinae, forming a clade with *Atrociraptor*, *Bambiraptor*, and *Saurornitholestes*. Geometric and linear morphometric analyses further reveal closer morphological similarities of the HSC Fm frontals with saurornitholestine frontals than with those of other dromaeosaurids. Although the holotype of *Atrociraptor marshalli* lacks frontals, the saurornitholestine affinities and stratigraphic occurrence of the new frontals offer some support for a referral to the former taxon. Under this assumption, the greater width and thickness of the HSC Fm frontals reveal that *Atrociraptor* had a wider and thicker skull roof than *Saurornitholestes*, as well as a deeper snout as previously described. Together, these features indicate that *Atrociraptor* had a robust skull compared to *Saurornitholestes*.

**Funding Sources** Eyes High Scholarship and Izaak Walton Killam Memorial Scholarship to JTV
NSERC Discovery Grant to DKZ

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Paleontological Management Poster Session
(Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**DEVELOPMENT OF A MULTIFUNCTIONAL FOSSIL PREPARATION FACILITY IN SUPPORT OF PALEONTOLOGICAL RESOURCE MANAGEMENT AND SCIENCE AT PETRIFIED FOREST NATIONAL PARK, ARIZONA (USA)**

Wagner, Deborah E., Parker, William G., Smith, Matthew E., Varela, Phillip J., Boudreau, Diana

Petrified Forest National Park, Holbrook, Arizona, United States

As a federal agency, Petrified Forest National Park (PEFO) has a duty to manage and protect its paleontological resources as stipulated by the National Park Service (NPS) Directive 77 and the Paleontological Resources Preservation Act of 2009, among other regulations and policies. Under this guidance, fossil specimens retained in the collection are subject to NPS policies like the Museum Handbook for the curation of museum objects. Quality fossil preparation facilities are essential to fulfill this duty and to facilitate research, exhibits, and other interpretive content. Despite a long history of fossil collecting within the park, PEFO did not have an adequate preparation facility prior to 2001, resulting in unusable collections. From modest beginnings consisting of a picnic table, a single air scribe, and a starting budget of $2000, the first designated preparation facility opened in 2003. Since then, the fossil preparation program has grown into a 1200 sq. ft. fully functional Main Laboratory with 6+ workstations and a 210 sq. ft. satellite Demonstration Lab, the primary purpose of which is to communicate scientific knowledge of park resources to the public through fossil preparation. This multifunctional laboratory system has a broad range of capabilities such as preparation by mechanical and chemical methods, histological sampling, and replication through traditional and digital methods. With a robust staff of full-time permanent preparators and trained paleontologists, PEFO's laboratories contribute a vital step in resource management and scientific advancement in the park and beyond, largely eliminating the need to rely on external partners for preparation. The addition of a permanent laboratory manager further refines workflow and allows the opportunity for professional growth within the NPS. PEFO's laboratories serve as a training space for museum professionals, seasonal employees, interns, and volunteers, many of which continue careers within the federal system or maintain partnerships with the NPS. Additionally, PEFO acts as a regional facility to assist with the preparation and conservation needs of neighboring federal agencies. This service allows for smaller park units lacking similar capabilities to fulfill their duties of fossil resource management. The PEFO model is a successful example of prioritizing the hiring of necessary staff and dedicating appropriate facilities and equipment in support of managing paleontological resources.

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Technical Session 2: Early Mammals & Carnivora (Wednesday, October 18, 2023, 8:00 AM)

**AN EARLY URSOID, *EOARCTOS VORAX*, FROM FITTERER RANCH, NORTH DAKOTA (EARLY OLIGOCENE) AND EARLY DIVERGENCE OF NORTH AMERICAN BASAL ARCTOIDS (CARNIVORA, CANIFORMIA)**

Wang, Xiaoming[1], Emry, Robert J.[2], Boyd, Clint A.[3], Person, Jeff J.[3], White, Stuart C.[4], Tedford, Richard H.[5]

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The infraorder Arctoidea represents the largest and most diverse (both living and extinct) clade in the suborder Caniformia (dog-like predators) including Ursoidea (bears and related species), Pinnipedia (seals, walruses, and other aquatic carnivorans), Musteloidea (skunk, red panda, raccoon, and weasel families), and Amphicyonidae (extinct bear dogs). Knowledge of the origins and initial diversifications of the arctoids have been mostly based on fossils from Europe but in recent years basal arctoids from North America have shown that the New World also played an important role in the early radiations of the caniform clade—North America is now known to produce some of the earliest members of nearly all major clades of Caniformia.

In the most recent Memoir of Journal of Vertebrate Paleontology, we described an exquisitely preserved male skeleton of a basal ursoid, *Eoarctos vorax*, which offers a unique window into the origin and early divergence of arctoids. Discovered from the Fitterer Ranch locality in the early Oligocene (Orellan to Whitneyan, ~32 Ma) Brule Formation of southwestern North Dakota, *Eoarctos* is at the base of the ursoid clade. Because of its basal position, *Eoarctos* inherits a suite of plesiomorphic characters from its miacid ancestors, allowing a rare chance to study the primitive conditions of early arctoids.

Combining several important extinct stem arctoids as well as a living representative of each arctoid families, we present a total-evidence (nuclear DNA and discrete morphological characters) Bayesian and parsimony analyses of Caniformia phylogeny. We recognize an endemic North American ursoid clade, family Subparictidae Baskin and Tedford, which includes *Eoarctos vorax* as its most derived member. We demonstrate the importance of North America as an early cradle of evolution for caniform carnivorans, including early precursors of Canidae, Amphicyonidae, Ursidae, Pinnipedia, and Musteloidea.

The excellently preserved skeleton of *Eoarctos* with few missing bones also permits a detailed examination of its entire skeletal system and functional morphology. We infer that *Eoarctos* is scansorial in locomotion, somewhat like a modern raccoon, retaining the ability to climb trees and lacking cursorial adaptations seen in the early canid *Hesperocyon*. *Eoarctos* shows clear signs of durophagous cranio-dental adaptations, presumably for an obligatory diet of mollusks, and frequent damage to shell-crushing premolars, plus associated dental infections.

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Technical Session 8: Mammal Paleoecology (Thursday, October 19, 2023, 1:45 PM)

**HOME ON THE RANGE: A MULTI-ISOTOPE INVESTIGATION OF UNGULATE RESOURCE PARTITIONING FROM ASHFALL FOSSIL BEDS, NEBRASKA, USA**

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We use carbon ($\delta^{13}C$), oxygen ($\delta^{18}O$), and strontium ($^{87}Sr/^{86}Sr$) to evaluate resource partitioning among ungulates from Ashfall Fossil Beds. Ashfall is a mid-Miocene (ca. 12 Ma) site in north-central Nebraska that preserves a volcanic ash-filled watering-hole entombing hundreds of skeletons. During the mid-late Miocene, North American ungulate communities were changing; meso- and brachydont species richness was high but decreasing, while hypsodont mixed-feeders or grazers were increasingly common. We sampled enamel from seven taxa: three horses (*Cormohipparion occidentale*, *Pliohippus pernix*, and *Pseudhipparion gratum*); two camels (*Procamelus grandis* and *Protolabis heterodontus*); one musk deer (*Longirostromeryx wellsi*); and one rhinoceros (*Teleoceras major*). Our $\delta^{13}C$ data (-9.6‰ to -6.9‰ on the VPDB scale) indicate that all seven taxa foraged in open $C_3$ habitats. The overall range in $^{87}Sr/^{86}Sr$ is small (0.70863-0.70898), while the range in oxygen is larger (-7.6‰ to -1.3‰ VPDB). Our (sub)mesodont taxa (*Longirostromeryx* and camels) had slightly, but insignificantly, lower $\delta^{13}C$ than hypsodont taxa (*Teleoceras* and horses). *Teleoceras* had significantly lower $\delta^{18}O$ and $^{87}Sr/^{86}Sr$ than the horses, and we interpret these differences as disparate water sources between *Teleoceras* and horse habitats. We suggest that *Teleoceras* lived in paludal environments (e.g., marshy wetlands) fed by rivers or aquifers with lower $\delta^{18}O$ and $^{87}Sr/^{86}Sr$, and horses foraged in open habitats (e.g., savannas) with more evaporation and atmospheric Sr input (increasing $\delta^{18}O$ and $^{87}Sr/^{86}Sr$). *Procamelus* and *Protolabis* $^{87}Sr/^{86}Sr$ aligns with the horses (as does *Procamelus* $\delta^{18}O$), but *Protolabis* $\delta^{18}O$ is anomalously low. We suggest the camels likely foraged on woody vegetation in similar habitats as horses, though our interpretations are limited due to small sample sizes (N=1 each). *Longirostromeryx* had intermediate $^{87}Sr/^{86}Sr$ but a wide $\delta^{18}O$ range, which suggests they may have foraged in multiple habitats. These results exemplify how $^{87}Sr/^{86}Sr$ can complement more traditional $\delta^{13}C$ and $\delta^{18}O$. Even in open mostly-$C_3$ and geologically homogenous landscapes, $^{87}Sr/^{86}Sr$ can provide novel insight into foraging areas and spatial partitioning among taxa. We recommend including $^{87}Sr/^{86}Sr$ in future paleoecological investigations.

**Funding Sources** Funding provided by U Cincinnati Sigma Xi chapter, U Cincinnati Geosciences department, Geological Society of America, and Western Interior Paleontological Society.

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Technical Session 19: Theropods - II (Saturday, October 21, 2023, 1:45 PM)

## NEW INFORMATION ON THE CRANIAL ANATOMY OF *TORVOSAURUS* (THEROPODA: MEGALOSAURIDAE) FROM THE UPPER JURASSIC MORRISON FORMATION

Warner-Cowgill, Ethan[1], Loewen, Mark[2], Storrs, Glenn W.[3], Lamanna, Matthew[4]

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A new associated skeleton of the rare Upper Jurassic megalosaurid theropod dinosaur *Torvosaurus* has been recovered from the Brushy Basin Member of the Morrison Formation in northwest Colorado. With 55 percent of the skeleton represented, it is among the most complete megalosaurid specimens known and includes the right maxilla, the articulated right postdentary hemimandible (including the surangular, articular, and prearticular), all vertebrae from the fifth cervical through the third caudal, numerous cervical and dorsal ribs, the right scapula, the furcula, the complete pelvis, the left femur, and parts of the right pes. Because no complete maxillae or posterior mandibles are otherwise known for *Torvosaurus* (or any megalosaurid), the new specimen provides novel insights into the cranial anatomy of this taxon. The mandible of *Torvosaurus* has a short retroarticular process and a small surangular foramen. The maxilla is substantially longer than previously recognized, with an elongate posterior facet for articulation with the jugal. The antorbital fossa extended posteriorly from the maxilla onto a large surface of the anterior part of the jugal and the ventral area of the lacrimal. There are several indications that the main body of the maxilla was pneumatic, as was, by inference, the missing nasal. The maxilla of the new specimen shares the following traits with those of *Torvosaurus tanneri* from the topotype locality at Dry Mesa Quarry (Morrison Formation, Colorado) and the holotype and referred specimens of *Torvosaurus gurneyi* from the Upper Jurassic Lourinhã Formation of Portugal: a shallow maxillary fossa, a laterodorsal ridge dividing the space lateral to the maxillary fossa at the base of the ascending ramus, a tall interdental wall dorsal to alveolus 3, and a large neurovascular opening on the dorsomedial portion of the posterior ramus. Previously claimed discrepancies between the maxillae of *T. tanneri* and *T. gurneyi* are questionable, as they result from the incomplete (i.e., number of maxillary alveoli) and poorly preserved (i.e., ventrally coincident alveolar margins) state of the *T. tanneri* maxilla from Dry Mesa Quarry. When considered in light of previously described cranial elements, the new specimen indicates that *Torvosaurus* had a long, low skull that departs substantially from earlier reconstructions, and that may have implications for interpreting ecomorphological differences among the highly diverse theropod fauna of the Morrison Formation.

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Technical Session 4: Dinosaur Soft Tissues (Wednesday, October 18, 2023, 1:45 PM)

## ISOTOPE PALEOECOLOGY OF DUCK-BILLED DINOSAURS (ORNITHISCHIA: HADROSAURIDAE) FROM THE UPPER CAMPANIAN DINOSAUR PARK FORMATION

Wasserlauf, Joshua Z.[1], Mallon, Jordan[2], Cullen, Thomas[3], Therrien, François[4], Cousens, Brian[1], Bataille, Clément[5]

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On account of their abundance in Upper Cretaceous deposits, the duck-billed hadrosaurids are among the best-studied dinosaur groups. Nevertheless, many aspects of their ecology remain debated, including range size, possible niche partitioning among sympatric species, and ontogenetic niche shifts. Prior studies of hadrosauroid bonebeds have also led to hypotheses that at least some species may have formed distinct herds based on ontogenetic stage, with juveniles found in bonebeds distinct from later ontogenetic stages, even after accounting for taphonomic effects.

In this study, we measured isotope composition in hadrosaurid tooth enamel from several individuals from the Dinosaur Park Formation of Alberta, of various ages and sub-familial affinities, to test for differences in the paleoecology of hadrosaurines and lambeosaurines, as well as for changes in the ecology of these animals through ontogeny. Because hadrosaurid dental batteries contain multiple generations of teeth, formed across multiple years, sampling the growth record of these teeth allows seasonal, annual, and multi-year patterns to be recorded.

Preliminary analyses of the enamel isotopic signatures reveal a detectable shift in average $^{87}Sr/^{86}Sr$, $\delta^{18}O$, and $\delta^{13}C$ from juveniles to adults, both in absolute values and in the amount of dispersion around each value. Ranges for $\delta^{13}C$, $\delta^{18}O$, and $^{87}Sr/^{86}Sr$ signals are considerably more constrained in the juvenile samples than in values obtained for adults. Greater dispersion in $^{87}Sr/^{86}Sr$ and $\delta^{18}O$ ranges in both lambeosaurine and hadrosaurine adults may indicate a shift to more widespread/wide-ranging feeding behaviors. The analyzed juvenile specimen exhibits a more positive mean $\delta^{13}C$ than the adults, contrary to a predicted depletion in the signal consistent with feeding on plants under dense canopy, but potentially related to or offset by other habitat factors such as feeding on more osmotically stressed plants in coastal forest/mangrove forest settings. Finally, we observe distinct seasonal profiles of $\delta^{13}C$ and $\delta^{18}O$ between hadrosaurines and lambeosaurines, with some specimens demonstrating positive correlations between these two signals and others exhibiting an inverse correlation. These findings may reflect divergent use of landscape and habitat resources between the two sub-families.

**Funding Sources** Carleton University Department of Earth Sciences, NSERC, and the Jurassic Foundation

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

## DIETARY MODIFICATIONS OF THE TEETH IN THE EARLY MIOCENE STENOMYLINE CAMELS (CAMELIDAE: ARTIODACTYLA)

Watmore, Kristin I.[1], Prothero, Donald R.[2]

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Angeles County, Los Angeles, California, United States

The stenomylines were a small group of early Miocene gazelle-like camels that developed extremely hypsodont, or high-crowned teeth. Previous authors measured the tooth crown height and mesowear of *Stenomylus* itself but did not include a study of the even more hypsodont genera *Rakomylus* and particularly *Blickomylus*. We measured the height index (HI = total tooth height of unworn m3/transverse width of m3) and estimated the mesowear of early camelids such as *Poebrotherium*, plus the basal stenomyline *Pseudolabis*, which had brachydont teeth (HI < 2) and relatively high cusp relief. As previously reported, *Stenomylus* has a HI as high as 4 and slightly more mesowear (levels 3-4). Similarly, *Rakomylus* has a HI = 4 and mesowear values around 5. But *Blickomylus* was dramatically more hypsodont, with a HI as high as 6.5 on the least-worn teeth (the same as the most hypsodont horses of the later Miocene) and a mesowear index of 6 (completely flat tooth-crowns with no cusp relief). This suggests that *Blickomylus* had an extremely abrasive diet, similar to the most hypsodont horses and ruminants of the Miocene. In fact, it is the most hypsodont animal of the early Miocene, at a time when horses like *Parahippus* had low-crowned teeth. It is unclear why such high-crowned teeth were selected for in *Blickomylus* in the early Miocene, as they would have been high-crowned before the extensive savanna grasslands had appeared. However, it is striking that this only occurs in the Zia Sand of New Mexico and in central Utah, but is unknown in High Plains deposits of Nebraska, Colorado, and South Dakota, which yields the greatest diversity of Hemingfordian mammals, including many other camel groups. Possibly, *Blickomylus* lived on a diet of plants covered with abrasive materials in New Mexico and Utah, but not in the northern High Plains.

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Colbert Poster Prize Session

**EVOLUTIONARY PATTERNS OF SIMPLIFICATION AND DIVERSIFICATION IN THE TETRAPOD LOWER JAW**

Watt, Emily C.[1], Felice, Ryan[2], Goswami, Anjali[1]

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Tetrapods (limbed vertebrates) are a diverse clade that originated around 390Ma following the water-to-land transition and are seen today in over 30,000 species of amphibians, reptiles and birds, and mammals. They have exploited an extraordinary range of ecological niches over this time, achieving a global distribution and reaching the largest body sizes on land, in the air, and in water. To achieve such global ecological breadth, the tetrapod skeleton has successively adapted, morphologically and functionally. The lower jaw is particularly interesting as the primary function, feeding, has remained the same across all tetrapods. In order to understand the morphological and functional evolution of the jaw, we must first understand the compositional evolution; that is, how the composition of the jaw has changed throughout Tetrapoda. We wanted to understand whether there was an initial burst of diversification in jaw composition at the base of Tetrapoda, whether Dollo’s law of trait canalisation or Williston’s law of simplification hold true, whether jaw composition is more complex now than in the past, and whether the bony and cartilaginous elements in the jaw and the teeth coevolved. We coded the presence or absence of lower jaw elements for over 1000 tetrapod species, representing family level sampling across Tetrapoda where possible. We also coded the presence and absence of teeth on variably tooth-bearing elements, and other characters that could be identified across the tetrapod tree such as the presence or absence of a beak or a mandibular fenestra. We estimated ancestral states, calculated disparity through time, modelled trait co-evolution, finding patterns suggesting an initial burst of diversity in the earliest parts of the clade followed by simplification of jaw composition towards static within-group jaw compositions in the extant clades. We found that there have been losses in elements in nearly every tetrapod clade, but also multiple gains across the tree. Tooth-bearing elements have unilaterally decreased, resulting in simpler dental compositions towards the extant tetrapods. Our results demonstrate that the lower jaw has undergone significant compositional evolution over the last 390 million years, experiencing much higher diversity in the early evolution of the clade, and successively adapting towards an overall simplified mandibular composition seen across living tetrapods.

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Technical Session 17: Afrotheria & Mammal Macroevolution (Saturday, October 21, 2023, 8:00 AM)

## ON THE ROLE OF TECTONICS AND CLIMATE IN STIMULATING THE CRETACEOUS DIVERSIFICATION OF MAMMALS

Weaver, Lucas N., Badgley, Catherine

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Mammals rose to prominence in terrestrial ecosystems after the Cretaceous-Paleogene mass extinction, but the mammalian lineages characteristic of Paleogene faunas began their evolutionary and ecological diversification in the Late Cretaceous, coincident with the rise of angiosperms. This burst in biodiversity on land has been termed the Cretaceous (or Angiosperm) Terrestrial Revolution, but the mechanisms underlying its initiation remain opaque. Here, we compile data from the fossil and rock records of western North America to explore the role that tectonism and climate might have played in catalyzing the rise of modern-aspect terrestrial biodiversity, especially that of mammals and angiosperms. We find that the acceleration of mammal and angiosperms species richness in the Late Cretaceous mirrors the acceleration of tectonic processes that formed the Rocky Mountains. Increases in both mammal and angiosperm diversity also occurred during the 'middle-Cretaceous hothouse' climate and the zenith of Western-Interior-Seaway transgression, the latter being a period when the availability of lowland habitats was at its minimum, and oscillatory transgression-regression cycles would have frequently forced upland range shifts among lowland populations. Mammals' increase in species richness during this interval does not appear to be a taphonomic artifact—some of the largest spikes in diversity occur when the available mammal-bearing fossil localities are sparse. Mountainous regions are biodiversity hotspots today and have been identified as engines for evolutionary radiations in the geologic past; thus, we propose that the Cretaceous/Angiosperm Terrestrial Revolution was ultimately catalyzed by accelerated tectonism and enhanced via consequent changes to landscapes and climate. At the basin scale we predict that (1) increases in mammalian diversity through the Late Cretaceous should be positively correlated with rates of tectonic uplift, (2) mountain-proximal mammalian assemblages should exceed the diversity of coeval mountain-distal assemblages, especially in the latest Cretaceous, and (3) endemism should increase from the latest Cretaceous to early Paleogene as Laramide mountain belts fragmented the Western Interior. Empirical tests of these predictions will require increased fossil collecting in under-sampled regions and time intervals, description and systematic study of existing collections, and basin-scale integration of geological and paleontological data.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

## XENARTHRAN MORPHOLOGICAL DISPARITY AND IMPLICATIONS FOR CINGULATE TAXONOMY

Weber, Andrew D., Croft, Darin A.

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Xenarthra is one of four superorders of placental mammals and is composed of two orders*:* Cingulata (armadillos, pampatheres, and glyptodonts) and Pilosa (sloths and anteaters). The extant diversity of xenarthrans (14 genera and 30 species) is far surpassed by the diversity of extinct representatives. Recent molecular phylogenetic analyses have called into question traditional taxonomic arrangements of cingulates and have proposed dividing the group into two major clades: Dasypodidae, consisting solely of *Dasypus* spp., and Chlamyphoridae, including all other extant armadillos plus extinct glyptodonts (traditionally recognized as a separate family). This proposal has been criticized for lumping most cingulate morphological diversity into a single family (Chlamyphoridae), in stark contrast to its sister-group, Pilosa, which includes seven family-level groups. An alternative taxonomic scheme for cingulates would recognize four families of extant armadillos plus Glyptodontidae (and several other extinct families). In order to test the idea that the morphological diversity (= disparity) of these two groups is similar, we quantified the disparity of cingulates and pilosans.

Morphology was quantified using 15 multistate craniodental, postcranial, and dermal armor characters, focusing on features likely to reflect ecological/functional adaptations. We coded eight extant and fourteen extinct xenarthrans at the genus level, including 10 cingulates and 12 pilosans, and analyzed the matrix via correspondence analysis in PAST. Disparity was measured as the area occupied by each clade in a plot of the first two axes from this analysis, which together accounted for 61.4% of the total variation. Disparity of cingulates (6.30) was less than that of pilosans (7.22) but greater than that of sloths (5.83). Sloths (folivorans) are currently divided among five highly disparate families, implying that a similar number of families should be recognized among cingulates. That would not be the case if the recent Dasypodidae-Chlamyphoridae classification were followed. Recognizing greater familial diversity among cingulates would also result in family-level divergence dates comparable to those of other mammal groups. To our knowledge, this is the first study to quantify morphology of xenarthrans in order to compare disparities of different clades.

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Technical Session 2: Early Mammals & Carnivora (Wednesday, October 18, 2023, 8:00 AM)

**ETHMOTURBINALS OF LATE CRETACEOUS *MENISCOESSUS ROBUSTUS* (MULTITUBERCULATA: CIMOLODONTA) AND PALEOECOLOGICAL INFERENCE**

Weil, Anne, Claxton, Alexander

Anatomy and Cell Biology, OSU-CHS, Tulsa, Oklahoma, United States

A high-resolution CT scan of NSM 20436 (National Museum of Nature and Science, Japan), a cranium of the Lancian multituberculate mammal *Meniscoessus robustus* recovered from The Sandy Site in the Hell Creek Formation of South Dakota, reveals that although the respiratory turbinals of this specimen were lost, more posterior olfactory turbinals are present and roughly in place, although the specimen is slightly deformed.

Turbinal bone appears distinct from bones enclosing the nasal cavity in having a finely trabeculated structure. In addition to a nasoturbinal, there are preserved portions of at least three ethmoturbinals that extend anteriorly. These are associated with ethmoturbinal ridges. There are seven additional ridges occurring in a fan arrangement visible on the ethmoid and orbitosphenoid, which are also associated with turbinal bone in the posterior and inferior portion of the olfactory recess.

Turbinals have not previously been described in Allotheria. Bony specks were observed in cross-sections of the cimolodontan *Kryptobaatar*, as were a tectal lamella of the nasoturbinal and basal lamellae of ethmoturbinals in the gondwanathere *Vintana*. Allotherian mammals had proportionally large olfactory bulbs, so the discovery of extensive olfactory turbinals confirms inferences by other authors.

*Meniscoessus robustus* fossils are most commonly recovered from stream channel deposits, and its molar morphology and enamel microwear are consistent with herbivory and even folivory, as is its relatively large size. The large extent of the olfactory turbinals suggests that *Meniscoessus* was not aquatic but had a longer taphonomic pathway into the deposits in which it is found. The turbinal morphology observed is most similar to that of insectivores among those living mammals from which turbinals have been published. This may reflect body size and relatively unspecialized rostral shape, rather than a shared diet. On the other hand, the ossified cribriform plate, some of which is preserved, may have been relatively large, which can correlate with a large olfactory genome.

**Funding Sources** Oklahoma State University Center for Health Sciences

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**CONVOLUTED HISTORY OF A COLLECTION: FOSSIL CARNIVORA FROM QUERCY, FRANCE IN THE SWEDISH MUSEUM OF NATURAL HISTORY**

Werdelin, Lars[1], Flink, Therese[1], Van Der Hoek, Julien[2]

[1]Palaeobiology, Swedish Museum of Natural History, Stockholm, Sweden, [2]University of Manchester, Manchester, United Kingdom

The Department of Palaeobiology, Swedish Museum of Natural History houses a substantial collection of fossil mammals from the Quercy region of southern France. This collection was accumulated between c.1870 and 1920 and includes about 600 cataloged specimens of Perissodactyla, Artiodactyla, Primates, Carnivora and Hyaenodonta. We here focus on carnivores, which comprise approximately 150 specimens assigned to Carnivora (18 genera) or Hyaenodonta (3 genera). The history of this collection is complex and only recently has rediscovered documentation allowed us to reconstruct its path from France to the Natural History Museum and to affirm its historical significance. The oldest specimens come from the collection of Russian paleontologist Vladimir Kovalevsky (1842-1883), an early evolutionist and one of the more intriguing figures in 19th century paleontology. Upon his death the material became the property of his wife, famed mathematician Sofya Kovalevskaya (1850-1891) who was professor at Stockholm College. She, in turn, left the collection to the Zootomical Institute of the College. The director of the Institute, Wilhelm Leche (1850-1927), had a strong interest in mammalian evolution and increased the collection through a series of purchases from fossil vendors such as Rossignol, Struer, and Krantz. After Leche's death in 1927 the collection was largely forgotten, although at least two specimens were sent on exchange to the Coryndon Museum, Nairobi in the early 1950s. Stockholm College was nationalized and became Stockholm University in 1960, followed five years later by the Museum of Natural History, which was previously part of the Academy of Sciences. At that time the collection was transferred to the museum, but due to lack of interest most of it was stored in the attic and few people had access to it. In 1985, the Department of Palaeozoology (as it was then) moved to new facilities at the museum and space became available for the entire Quercy collection. However, documentation was lacking for nearly all of the collection, which was known colloquially as the "Kovalevsky collection". The final phase of restoration came in 2021 when we rediscovered the original catalog cards from the Zootomical Institute that include information about locality, collector, and year for each specimen, allowing us to, for example, clarify how much of the collection actually originated with Kovalevsky.

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**DIETARY NICHES OF THE POSSUM FAMILIES (MARSUPIALIA) PRESENT IN THE ETADUNNA FORMATION OF SOUTH AUSTRALIA**

Wheat, Theodore C., Case, Judd A.

Biology, Eastern Washington University, Cheney, Washington, United States

The Lake Eyre Basin in South Australia holds Australia’s oldest known fossil marsupials in the Etadunna Formation, a formation that spans two million years from 23.3 to 25 MA. During that two-million-year period, many of the terrestrial marsupials present in the area underwent a transition in diet, likely brought on by a changing environment caused by a warming climate. However, it is unknown whether a similar change occurred to the marsupials like possums that live up in the canopy. Understanding this could help determine how extensive this change in the environment was.

In mammals, tooth morphology provides the best insight into a species’ dietary niche. In Australian possums, the third premolar in particular shows the greatest morphological diversity and is therefore the best indicator of the possum’s dietary niche. These premolars can be wide and bladed to small and conical to tall and canine-like. The size and shape of P3s can be correlated with diet through a ranked correlation like Spearman’s ranked correlation. Additionally, a microwear analysis can help further narrow down possible dietary niches. Microwear refers to the microscopic pits and grooves in teeth created by food substrate grinding against the teeth during chewing. The number, size, and distribution of pits and grooves are determined by how the animal chews and the physical qualities of the food, including its hardness, toughness, plasticity, and strength. The third premolars in possums also provide large occlusal surfaces, making them ideal candidates for studying microwear. Areas of 0.6 mm x 0.6 mm on the occlusal surfaces of the upper and lower third premolars were studied. *Burramys parvus,* a modern species of pygmy possum, has premolars with a high number of pits and scratches, and has a diet consisting of moths, grubs, and berries. *Pseudocheirops archeri,* the modern green ringtail possum, has a high ratio of scratches to pits, caused by its diet primarily composed of mature leaves.

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**PARTIAL CRANIUM AND ASSOCIATED TUSKS OF MIO-PLIOCENE *MAMMUT* (MAMMALIA, PROBOSCIDEA) FROM PASCAGOULA FORMATION IN TUNICA HILLS, LOUISIANA**

White, Connor D.

Geoscience, East Tennessee State University, Mandeville, Louisiana, United States

A partial cranium and associated tusks of a mastodon found in the Tunica Hills site in West Feliciana Parish, Louisiana is described and discussed. The specimen was cataloged as LSUMG-V-17901 and named the “Thompson Creek Mastodon.” LSUMG-

V-17901 was discovered in 2005 in the Pascagoula Formation, which was identified as Miocene in age, making it the first Miocene mastodon found in Louisiana and one of the few found in the Southeastern United States. Further examination of the various taxa discovered at the site supports a North American Land Mammal Age of Hemphillian 4 with a possible extension into Blancan 1, which would indicate that the geologic age of the Pascagoula Formation in Tunica Hills would be latest Miocene to earliest Pliocene. The morphology of the upper M2 and M3 indicate that the specimen belongs to the genus *Mammut*, and the wear state on the teeth indicate the specimen is within Laws Group XXII, which is equivalent to 39 +/- 2 AEY (African Elephant Years). The tusks of the Thompson Creek Mastodon are morphologically unusual because the tusks have a small girth for their length in comparison to other mastodons, are mostly straight with a slight upward curvature, and they are curved in two planes, which is a feature that is not typically found in mastodon tusks. The Thompson Creek Mastodon is identified as *Mammut matthewi*, based on morphological similarities to other specimens of the taxa that are similar in geologic age.

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Technical Session 6: Marine Reptiles (Wednesday, October 18, 2023, 1:45 PM)

**TOOTH SHAPE IN MESOZOIC MARINE REPTILES**

White, Joshua M.[1], Denham, Tim[2], Fischer, Valentin[3], McCurry, Matthew[4]

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Marine reptiles filled important ecological roles in the world's oceans throughout the Mesozoic, roles that were subsequently occupied by marine mammals after the Cretaceous/Palaeogene extinction event. One method of tracking changes in the ecological roles of species is by observing their dental morphology, traditionally done with qualitative analysis. This approach makes tracking shifts in diet through time challenging, however. Here, we generated a dental morphospace of various groups of marine reptile teeth using euclidean measurement based on the enamel crown on most known dental morphologies present in marine reptiles. Our results show most variation in tooth morphology occurs in tooth robusticity (75.5%), followed by tooth curvature (15.8%). The dental morphospace clusters on conical, slightly recurved region regardless of functional guild, taxonomic group and geological age. Furthermore, two regions of the morphospace; robust, recurved teeth and thin, straight teeth are unoccupied by species in the dataset, suggesting a trade-off between ability to withstand loads (robusticity) and puncture efficiency and grip. We observed considerable overlap in morphospace occupation across time and between taxonomic groups. Our results suggest that there are strong selective pressures causing convergent evolution in marine reptile dentition, but more work is required to map how changes in tooth shape influence functional abilities.

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Technical Session 1: Sauropod & Ornithischian Dinosaurs (Wednesday, October 18, 2023, 8:00 AM)

**NO MORE HORSING AROUND: A POSSIBLE EXPLANATION FOR THE UNUSUAL WEAR FACETS COMMONLY OBSERVED IN DIPLODOCOID SAUROPOD DINOSAURS.**

Whitlock, John A.

Biology, Mount Aloysius College, Cresson, Pennsylvania, United States

Sauropod dentitions have received significant attention for over a century, with the first investigations into the feeding behaviors of *Diplodocus* dating as far back as 1901. *Diplodocus* and its relatives are especially commonly represented, owing no doubt to their unusual, pencil-like dentition. One of the most interesting aspects of the dentition of these sauropods is the unusual wear facets that often, but not always, occur on the mesial upper dentition. These wear facets, rather than occurring on the labial surface as is expected from an orthal bite, occur as high-angled wear surfaces on the buccal surface. Numerous attempts to account for these facets have been put forward without any particularly satisfying explanation emerging.

However, a somewhat unusual dental pathology seen in horses may hold the key to unlocking the secrets of these facets. Unlike cows, whose broad muzzles have often been used as a point of comparison for

diplodocoids, horses retain upper incisors, which they use to nip food near ground level while selectively browsing. When kept in sandy or sparsely vegetated enclosures, horses will often develop high-angled distolabial wear facets on the upper dentition, often wearing through the dentine on the labial surface and into the pulp cavity. Superficially similar wear is also seen in “crib-biting” horses, when an object is grasped between the incisors and the head is retracted caudally; wear facets produced by crib-biting are lower-angle and more similar to normal wear facets produced by normal food acquisition.

Here, I suggest that close-cropping of vegetation on sandy or coarse soils are responsible for the facets seen in diplodocoids such as *Diplodocus* and *Nigersaurus* based upon the broad similarity in inferred feeding behavior and facet morphology. The rapid onset of significant dental issues caused by this wear in horses may also suggest an evolutionary pressure for the development of rapid tooth replacement rates in diplodocoid sauropods. Finally, the prevalence of these facets in *Diplodocus* and their apparent absence in *Apatosaurus* may further indicate that these animals fed preferentially on plants growing on different substrates or at different sward heights.

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Education & Outreach Poster Session (Saturday, October 21, 2023, 4:30 - 6:30 PM)

### THE EPIC JOURNEY OF PRIMATES: BUILDING A NEW EXHIBIT AND TOUR AT THE DUKE LEMUR CENTER MUSEUM OF NATURAL HISTORY

Whitman, Karie L., Marron, Alanna, Borths, Matthew R.

Duke Lemur Center Museum of Natural History, Duke University, Durham, North Carolina, United States

The evolutionary journey of primates is complex, as lineages disperse between continents and adapt to new ecosystems. The fossil collection at the Duke Lemur Center (DLC) is well positioned to tell this story using primate specimens from the Paleogene of North America and Africa, and the Neogene of Africa, South America, and Madagascar. Founded in 1977, the collection was primarily only accessible – and interpretable – to specialized researchers. Visitors and students unfamiliar with fragmentary fossils and obscure taxonomy faced the daunting task of keeping track of the primate journey while following staff through cabinets and drawers. This contrasted with significant education and outreach efforts at the DLC’s main campus, where non-invasive research on the colony of over 200 living lemurs was accessible to the public through tours, interpretive exhibits, and classroom outreach. Our goal was to work together with the DLC education team to fabricate an exhibit that helped visitors access our Big Idea: Humans and Lemurs Share an Evolutionary History That Spans the Globe. The exhibit space is relatively small and the taxa and time periods are unfamiliar to most visitors. We designed color-coding and symbols that are consistent throughout the exhibit and collection spaces to create a layered experience for visitors. A visit can focus on primate adaptations, ecological niches, plate tectonics, or the geological timescale – all science curriculum goals for different grade levels in North Carolina. The exhibit is also physically layered, with modern primate diversity at eye-level accompanied by infographics that summarize the anatomical distinctions between major clades. Displayed below modern specimens are fossil specimens, demonstrating how fossils are used to understand modern biodiversity and vice versa. This structure is disrupted in the Madagascar section, where subfossil lemur taxa are displayed alongside osteological specimens, emphasizing the recent extinction of Malagasy megafauna. This reinforces the DLC’s larger mission to understand and conserve remaining biodiversity. Exhibit materials were designed with the explicit goal of making them available for collaboration with international partners. The team trained volunteer docents to help visitors access the space, and the exhibit opened to visitors in May 2023. Visitors can provide feedback through a standardized form so we can evaluate exhibit materials and revise them in response to engagement.

**Funding Sources** IMLS MA-245704-OMS-20; NSF DBI 2023087; NC Science Museums Grant

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Technical Session 18: Synapsids (Saturday, October 21, 2023, 8:00 AM)

### BONE HISTOLOGY OF *SPHENACODON* (SYNAPSIDA: PELYCOSAURIA) PROVIDES INSIGHT INTO THE 'PELYCOSAUR'-THERAPSID TRANSITION

Whitney, Megan[1], Angielczyk, Kenneth D.[2], Huttenlocker, Adam[3]

[1]Department of Biology, Loyola University Chicago, Chicago, Illinois, United States, [2]Neguanee Integrative Research Center, Field Museum of Natural History, Chicago, Illinois, United States, [3]Department of Integrative Anatomical Sciences, University of Southern California, Los Angeles, California, United States

Non-mammalian synapsids are renowned for their fossil record that details the process by which mammalian features were acquired, making them an important evolutionary study system. Recent studies on morphological transitions in non-mammalian synapsids have indicated rather than consistent gradualism, there were key episodes in the evolution of mammalian traits during synapsid evolution. Specifically, there is a growing body of evidence that the 'pelycosaur'-to-therapsid transition documents morphologic changes that established a more "mammal-like" trajectory for synapsid evolution. Here, we compare the bone histology of *Sphenacodon* to similar-sized extant ectotherms and evaluate their growth patterns in a comparative framework.

Sphenacodontids are the sister group of Therapsida. As such, sphenacodontids bear a mosaic of primitive and derived morphologies making them an intriguing group to target histologically. *Sphenacodon* material from the Carboniferous-Permian Cutler Group has been well sampled and is re-examined here based on 12 sectioned humeri and femora. *Sphenacodon* limb cortices were moderately thick and record intervals of rapid growth punctuated by growth marks. Rapid growth in *Sphenacodon* is characterized by abundant vasculature that is organized longitudinally and radially, similar to large varanids. There is minimal osteonal deposition and the cortex is mainly composed of parallel-fibered bone with a predominantly longitudinal fiber orientation. Growth mark retrocalculation facilitates comparison to large ectotherm skeletochronologic data, showing close comparisons to *Varanus komodoensis* and *Alligator mississippiensis*.

Compared to other histologically sampled 'pelycosaurs,' large sphenacodontids, such as *Sphenacodon* and *Dimetrodon* likely experienced rapid growth, especially early in ontogeny, that transitioned to slower cyclic growth later in ontogeny. Importantly, however, compared to *Dimetrodon, Sphenacodon* had markedly more punctuated growth throughout its lifetime as evident by abundant mid-cortical growth marks. This suggests there were no "stereotyped" growth strategies and/or environmental interactions in Sphenacodontidae and early synapsids exhibited the full diversity of growth and life history strategies evident in nonavian reptiles today. The consistent rapid early growth within Sphenacodontidae may have provided a foundation upon which the more 'mammal-like' life histories observed in many therapsid groups evolved.

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**MAMMOTH MOBILITY AND LANDSCAPE USE: A REGIONAL META-ANALYSIS**

Widga, Chris[1], Harrington, Matthew[1], Esker, Donald A.[2]

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The provenance of paleoecological signals is important to analyses of paleoecological data and inferences of taxonomic relationships. Biogeographic studies and paleoecological analyses of proxy data are often based on the assumption that fossil records are relatively local to where they were found. However, movement patterns in modern vertebrates are determined by many biological and ecological variables, some of which are invisible in fossil contexts. In recent years, $^{87}Sr/^{86}Sr$ values of mammalian tissues have been used to directly address relative mobility in fossil mammals. The accuracy and precision of such studies is determined by: 1) the fidelity of the $^{87}Sr/^{86}Sr$ signal to time periods of biological interest, and 2) the accuracy and resolution of 'isoscapes' that provide estimates of geographic variability in available $^{87}Sr/^{86}Sr$.

It is a challenge to acquire serial isotope series with sub-annual precision from mammoth molars due to the geometry of tooth formation. Micromilling provides micron-scale vertical control in the acquisition of enamel samples allowing for seasonal-scale isotopic analyses. Although time and labor intensive, micromilled mammoth enamel series are now available from five localities (9 individuals spanning the last 100 ka) from the Great Plains and Midwest. This, combined with an updated $^{87}Sr/^{86}Sr$ isoscape for the region, allows us to directly explore mammoth mobility in the North American Midcontinent.

An $^{87}Sr/^{86}Sr$ isoscape was created by interpolating a surface from 400 modern plant and animal samples. This surface reflects first-order variability in $^{87}Sr/^{86}Sr$ from Wyoming to Ohio, and Alberta to Texas. Each mammoth locality was buffered with a radius reflecting the maximum home range size in modern *Loxodonta africana* (8700 $km^2$), providing metrics for what would be expected mammoths exhibited a scale of movement similar to modern *Loxodonta*. From these baseline expectations, two individuals (Waco, TX; Jones Spring, MO) show $^{87}Sr/^{86}Sr$ values that do not overlap with local values. These mammoths may represent one-way migration events (e.g., age-related dispersal). Seven individuals show a spread of $^{87}Sr/^{86}Sr$ values that is similar to the buffered isoscape (i.e., maximum home range size of modern elephants) indicating a scale of movement that is similar to modern African elephants.

**Funding Sources** Geological Society of America, Graduate Research awards to M.H. and D.E. Center of Excellence in Paleontology, East Tennessee State University.

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Technical Session 7: Birds (Thursday, October 19, 2023, 8:00 AM)

### QUANTITATIVE ANALYSIS OF FLIGHT CAPACITY IN A PALEOCENE STEM PALAEOGNATH

Widrig, Klara E.[1], James, Helen F.[2], Field, Daniel J.[1]

[1]Earth Sciences, University of Cambridge, Cambridge, United Kingdom, [2]Division of Birds, Smithsonian National Museum of Natural History, Washington, D. C., District of Columbia, United States

Lithornithids are presumably flying stem palaeognaths known from the Paleogene. Among extant palaeognaths, which include flightless ratites such as ostriches, only tinamous (Tinamidae) are capable of flight. These superficially partridge-like birds are reluctant fliers, utilizing anaerobic burst flight over short distances to escape predators. The flight capabilities of stem palaeognaths are important for making sense of palaeognath biogeography, because the phylogenetic relationships of extant palaeognaths imply that their stem group representatives were capable dispersers to explain their presence on isolated landmasses such as Australia and New Zealand. Here, we quantitatively investigate the flight capabilities and ecology of *Lithornis promiscuus* using two methods shown to effectively predict these traits in extant birds: the ratio of forelimb to hindlimb length, and geometric morphometric shape analysis of elements of the flight apparatus. Our calculated forelimb:hindlimb ratio of –0.0387 indicates a slightly higher investment in hindlimbs than forelimbs, consistent with a ground-feeding ecology but inconsistent with flightlessness. Our geometric morphometric analysis rejects tinamou-like burst flight and is consistent with aerobic flight styles such as continuous flapping. Among extant birds, the humerus is unlike that of tinamous, and is instead similar to phylogenetically divergent taxa such as psittacids and columbids; the sternum is highly unlike that of tinamous, and bears resemblance to some extant marine birds. Unlike tinamous, these groups are capable of long-distance flight. Additionally, the sternum also shows similarity with the near-crown Cretaceous ornithurine *Ichthyornis*, suggesting that the *Lithornis* sternum may exhibit aspects of its three-dimensional morphology that are plesiomorphic for crown birds.

**Funding Sources** This research was supported by a SIFP Graduate Student Fellowship to K.E.W. and a UK Research and Innovation Future Leaders Fellowship (MR/S032177/1) to D.J.F.

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Technical Session 14: Crocodylomorphs & Turtles (Friday, October 20, 2023, 1:45 PM)

### MODELING EVOLUTIONARY TRANSITIONS IN THE CROCODYLIFORM FEEDING APPARATUS

Wilberg, Eric[1], Godoy, Pedro L.[2], Turner, Alan H.[1], Smaers, Jeroen B.[1]

[1]Stony Brook University, Stony Brook, New York, United States, [2]University of São Paulo, São Paulo, Brazil

Crocodyliforms filled a variety of ecological niches throughout their evolutionary history and explored a broad range of cranial morphologies, particularly in relation to the form of the rostrum and supratemporal fossa (STF). These character complexes are functionally related, with the snout acting as the prey capture apparatus and the STF as the origin for the pseudotemporalis and/or adductor mandibulae externus profundus musculature. Prior work has suggested a correlation between snout shape and STF size – taxa with long slender snouts tend to have larger STF, possibly related to the importance of the aforementioned muscles in their prey capture strategy. To investigate evolutionary scaling patterns of these modules we quantified snout and STF shape in 123 taxa using geometric morphometric methods. We then modeled the evolution of these modules on a time-scaled tree, inferring shifts in allometric patterning under a Bayesian multi-regime Ornstein Uhlenbeck modeling approach. We assessed the significance of detected shifts using phylogenetic ANCOVA. Our results indicate three significant shifts in covariation between STF and snout length. The primary shift occurs just outside of Eusuchia. In comparison with non-eusuchian crocodyliforms, eusuchians exhibit less change in STF size relative to snout length. The eusuchian regime convergently evolved among the peirosaurid notosuchians. Other significant shifts were detected at the origin of Metriorhynchidae, and among the extinct duck-faced caimans. The pattern and significance of these shifts were robust to topological changes in the position of Thalattosuchia and to branch-length variation.

As these modules relate to feeding, this shift in phenotypic covariation may indicate an important transition in the evolution of the crocodyliform feeding apparatus near the origin of Eusuchia. That non-eusuchian crocodyliforms tend to have larger STF suggests a reliance on muscles occupying this space, while the relatively smaller STF of eusuchians may mark a shift to an increased role of the pterygoideus musculature responsible for the extreme bite forces of extant crocodylians. The timing of this transition matches closely with a prior study modeling the evolution of crocodyliform bite force based on different osteological proxies. Collectively this suggests that the modern crocodylian feeding apparatus developed around the origin of the Eusuchia, coincident with a trend towards bite-force maximization.

**Funding Sources** National Science Foundation grant NSF-DEB 1754596

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Technical Session 21: Squamates (Saturday, October 21, 2023, 1:45 PM)

**ADAPTED BIOGEOGRAPHY METHOD UTILIZING BOTH PALEOGEOGRAPHIC AND FOSSIL DATA RECONSTRUCTS A EUROPEAN AND NORTHEASTERN ASIAN ORIGIN OF SQUAMATA**

Wilenzik, Ian, Pyron, R. Alexander

The George Washington University, Washington, District of Columbia, United States

Even though Squamata is one of the most diverse clades of tetrapods, little is known about the historical biogeography or the ancestral range of the group. Previous attempts utilized methods like DEC+J as the model of choice, where fossils were used as nodal constraints. In our study, we adapted a methodology originally used to jointly estimate biogeographic ancestral range estimation and divergence times to focus solely on ancestral range estimation on phylogenies with predetermined divergence times, in a model we call CANDiELand. The model centers around the idea of communicating classes, in which the distances between 25 discrete areas are qualified in a Q matrix that can change based on their positions in 26 time slices. Our model also uses fossils as terminal taxa, rather than as constraints for nodes, utilizing their phylogenetic, as well as their biogeographic, information. Since there is major disagreement on the positions of major groups within Squamata, we ran three different phylogenies, testing three different morphological matrices in addition to molecular data. We found that all three show a European and/or northeastern Asian origin for Squamata, with different models reconstructing a complex web of dispersals, eventually achieving the modern near-global distribution of modern Squamata. Our results show the importance of these areas in the early evolution of Squamata under multiple hypotheses of evolutionary relationships within the clade.

**Funding Sources** Harlan Fund at George Washington University

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Paleontological Management Poster Session (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**REINVENTING THE UNITED STATES FOREST SERVICE PALEONTOLOGY GEODATABASE**

Wilkins, William J.[1], Schumacher, Bruce[1], Love, Timothy[1], Hewitt, Reid[2], Lennox, Dan[2], Russon, Holly[2], Skeans, Elii[2]

[1]Lands, Minerals, & Geology Management, US Forest Service, Lakewood, Colorado, United States, [2]Xentity Corporation, Golden, Colorado, United States

The USDA Forest Service (USFS) manages 193 million acres of land, nearly half of which encompasses sedimentary geology with potential for paleontological resources. Thousands of fossil localities are known on USFS lands from historical literary sources, however only a fraction of this is documented within a national geodatabase. With only three titled paleontologists, the USFS relies on non-federal partners (museums and universities) as the primary workforce to undertake inventory and preservation work. Maintaining records for fossil specimens (federal property in perpetuity) and source areas is especially challenging with respect to legacy collections accumulated during the 20th century, a time when a paleontology program did not exist within the USFS (beginning in 1990's). Beginning in 2010 the USFS began capturing fossil locality information using ArcGIS software and a custom add-in tool called PaleoEx. PaleoEx is a graphical user interface for recording geospatial records of fossil localities and specimens but lacks connection to USFS database servers. The add-in has several minimally utilized data fields, has experienced delays due to ESRI software changes, and is limited to internal use by USFS paleontology staff. To stay current with evolving technologies and concomitant best practices, the USFS and Xentity Corporation are developing a new database solution and tools for transforming and uploading large amounts of paleontological data.

The new solution offers a simplified and streamlined data entry and reporting process that leverages USFS approved and supported Esri software. The database will be housed in the USFS Enterprise Data Warehouse (EDW) with flexible and secure data entry procedures allowing access to non-USFS permit holders. Field data collection applications will give researchers and managers the ability to upload data gathered in the field, enhancing the efficiency of digitally documenting stewardship efforts. These changes will greatly increase the ability to build and maintain the USFS Paleontology Geodatabase and enable collaborative use of digital information available from partner organizations. With appreciation, the USFS invites institutions that house paleontology collections from National Forest System lands to share legacy locality and/or specimen information.

**Funding Sources** United States Department of Agriculture Forest Service

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Education & Outreach Poster Session (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**AN EXEMPLAR IN SCIENCE EDUCATION: 25 YEARS OF PALEOFEST AND COUNTING**

Williams, Scott A.[1], Mathews, Joshua[2], Tremaine, Katie M.[3]

[1]Exhibitions, Museum of the Rockies, Bozeman, Montana, United States, [2]Paleontology, Burpee Museum of Natural History, Rockford, Illinois, United States, [3]Earth Science Department, Montana State University, Bozeman, Montana, United States

In 1999 Burpee Museum of Natural History created PaleoFest as a "science meets the street" educational program to celebrate and make accessible to everyone the science of paleontology. PaleoFest initially catered to fossil collectors and enthusiasts but eventually evolved into a wholistic educational program with something for every interest and age level. The annual spring event offers a weekend of activities consisting of five core components: a Member's Appreciation event; paleo-passport stations throughout the museum; family-friendly fossil workshops; two days of presentations for general audiences given by up to 20 paleontologists; and a Saturday evening keynote/dinner lecture. PaleoFest's versatility allows it to span hundreds of millions of years or be focused with symposium-style presentations. Past PaleoFests had symposia with "End of the Dinosaurs"; Late Cretaceous; "Rise of the Dinosaurs"; Late Triassic and Early Jurassic; and "Reign of the Mammals" Cenozoic themes. In 2016 PaleoFest used its platform to address issues of equity. After several years of PaleoFest having nearly 80% male presenters, the first "Women in Paleontology" Symposium was held; of 20 presenters the only male speaker was Dr. Hesham Sallam (Mansoura University), who spoke about teaching the first women paleontologists in Egypt. Following this, PaleoFest endeavored to have equal representation for presenters. PaleoFest often publishes abstracts and can also easily be a venue for student poster presentations, offering up-and-coming students the opportunity to share their science with the public. Many kids and teens who started coming to PaleoFest went on to college to pursue a career in science- even becoming some of the most recognized paleontologists in the world. More recently, PaleoFest incorporated live streams to allow paleontologist-led panel discussions with elementary schools from across the country. The PaleoFest template is made to be shared, so other institutions can take and modify components they like, making them unique to their institution. Many other museums have adapted their own successful events: DinoFest, Dinosaurs and MOR, Permian Fest, Dino ShinDig, and more. These institutions' results are the same: hundreds to thousands of kids and adults sharing their love for and interest in paleontology. 2023 saw the 25th PaleoFest, with every indication this event will thrive, be emulated and shared, and continue to serve as an exemplary educational program.

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Technical Session 13: Fishes - Actinopterygians (Friday, October 20, 2023, 1:45 PM)

**FRESHWATER FISH AND THE CRETACEOUS/PALEOGENE BOUNDARY: A CRITICAL, INTEGRATIVE ASSESSMENT OF SURVIVORSHIP PATTERNS**

Wilson, Jacob D.[1], Huang, EJ[1], Lyson, Tyler[2], Bever, Gabriel S.[1]

[1]Center for Functional Anatomy and Evolution, Johns Hopkins School of Medicine, Baltimore, Maryland, United States, [2]Earth Sciences, Denver Museum of Nature and Science, Denver, Colorado, United States

Arguably, the most compelling questions regarding mass extinctions are not what went extinct and why, but rather what survived and why. The biotic transition defining the Cretaceous/Paleogene (K/Pg) boundary offers many examples of differential survival and post-event recovery that can deepen our understanding of the extinction event and its role in shaping the modern biota. One such example is Actinopterygii. Here, marine fish are generally characterized by extinction of large, predatory forms and post-K/Pg diversification of some major clades, whereas for freshwater lineages, the general consensus is that the event had little impact on diversity. The data on which this marine-freshwater disparity is based, however, are not equally mature, with the disparity reflecting the extent to which the fossil record of freshwater fish is a product of screen-washing efforts. Such highly fragmentary and isolated elements are difficult to meaningfully incorporate in tree-based analyses, forcing morphotype assessments that often extend across significant stratigraphic and geographic distances.

We set out to test the stability hypothesis for freshwater fish across the K/PG using an integrated approach that considers both fossils and the molecular sequences of extant species. Our fossil analysis uses morphotypes of isolated vertebral centra recovered from freshwater sediments. The analysis is an important step forward in that the specimens are from West Bijou, Denver Basin, Colorado, a unique locality that has a well-documented K/Pg boundary with primary markers of the asteroid impact and a precise chronostratigraphic framework thanks to abundant U-Pb-dated ash beds and high-resolution magnetostratigraphy. We also used a broadly sampled, time-calibrated molecular phylogeny of actinopterygian diversity to explicitly search for post-extinction spikes in diversification that would signal a significant K/Pg influence. Preliminary data from our analyses suggest that the stability hypothesis has merit, and that freshwater lineages were buffered to the environmental perturbations of the K/Pg event. Our understanding of the actinopterygian skeleton and its variational dynamics still lies below the level needed to fully realize the heuristic potential of the freshwater fossil record. This form of integrative analysis is motivational as it demonstrates what meeting this potential could mean for our understanding of the modern biota and its deep history.

**Funding Sources** The Explorers Club, Paleontological Society, Lyda Hill Philanthropies

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**NEW CRANIAL MATERIAL OF THE CENTROSAURINE CERATOPSID DINOSAUR *PACHYRHINOSAURUS PEROTORUM* FROM THE CAMPANIAN PRINCE CREEK FORMATION, ALASKA**

Wilson, John[1], Ryan, Michael J.[2], Erickson, Gregory M.[3], Druckenmiller, Patrick S.[1]

[1]Museum of the North, University of Alaska Fairbanks, Fairbanks, Alaska, United States, [2]Department of Earth Sciences, Carleton University, Ottawa, Ontario, Canada, [3]Department of Biological Science, Florida State University, Tallahassee, Florida, United States

Elaborately ornamented ceratopsids are among the most commonly recovered dinosaurs from the Late Cretaceous of North America. Among these, the centrosaurine *Pachyrhinosaurus perotorum* from the Prince Creek Formation of northern Alaska is noteworthy as both the highest latitude ceratopsid known and one of the last to evolve prior to the end of the Cretaceous. *P. perotorum* is primarily known from an extensive monodominant bonebed that has produced numerous partial skulls, mostly of adult individuals, preserving the facial region and skull roof. In contrast, the geologically oldest species of *Pachyrhinosaurus, P. lakustai*, from the Wapiti Formation of Alberta, is known from essentially complete cranial remains, including complete parietals, as well as an extensive ontogenetic series. Here we describe new cranial material of *P. perotorum* which contributes novel anatomical information and further insight into the cranial ontogeny of this species. A partial proximal midline parietal bar bears a low, anteroposteriorly elongate, and dorsally rounded ornamental mass, demonstrating that midline parietal bar horns were present in species of *Pachyrhinosaurus* beyond *P. lakustai*. Midline parietal bar horns of *P. lakustai*, however, are typically dorsoventrally taller and pointed, and often occur in clusters of multiple horn-like projections, and therefore the condition of the new *P. perotorum* midline parietal bar horn may further distinguish it from the geologically older *P. lakustai*. However, because the newly described specimen represents the first known midline parietal bar horn of *P. perotorum*, the range of morphological variation of this feature is unknown. An additional partial subadult cranium, preserving most of the nasal boss and both supraorbital bosses, likely represents one of the least mature individuals known of *P. perotorum*. This specimen largely lacks the pronounced palisaded texture typical of the lateral surfaces of adult nasal bosses, and likewise lacks a prominent basal sulcus demarcating the ventral margin of the nasal boss. The nasal and supraorbital bosses show weak dorsal inflation, and do not converge upon each other as in adult individuals. Finally, the structure of the ridges on the dorsal boss surfaces mirrors that of subadult specimens of *Achelousaurus horneri* from the Two Medicine Formation of Montana, showing developmental congruence with this geologically older, possible ancestor of *Pachyrhinosaurus*.

**Funding Sources** National Science Foundation EAR1226730 and EAR 1736515

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Education & Outreach Poster Session (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**ASSESSING AND IMPROVING SCIENCE STUDENT #SCICOMM SKILLS**

Wilson, Laura E.[1], Link, Kale[2], O'Dell, Kaiden[2], Moore, Todd W.[2]

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As the population becomes increasingly connected online, there is a growing need for effective science communication on social media platforms (referred to here as #SciComm). The goal of our project is to assess and facilitate #SciComm skill development among science students at Fort Hays State University (FHSU) to enhance their professional development opportunities. To do this, we investigated what #SciComm-related skills students are already exposed to through course work and then developed a workshop to train science majors on how to communicate scientific ideas to the public using popular social media platforms.

In the Fall 2022 semester, we deployed a survey to FHSU undergraduate and graduate science students to gauge their experiences with #SciComm. Questions included whether students have received forma instruction in communicating science to non-scientists and which classes incorporate building these skills. We also collected data on what #SciComm content students consume on social media and what skills they want to develop. Most students (78%) reported that they have not received any formal training in online science communication. However, many had practiced skills needed in science communication, like writing plain-language summaries, creating infographics, or giving a formal presentation to a non-science audience, demonstrating a disconnect in student metacognition between class assignments and professional development skills. Additionally, a majority of students (68%) reported that they want more hands-on #SciComm training.

Using these results, we developed and delivered a workshop during the Spring 2023 semester to provide a professional development opportunity for students interested in #SciComm. During the workshop, students practiced identifying audiences, reducing jargon, and crafting narratives. All workshop participants who completed the post-workshop survey reported that they think science communication is an important skill needed for a future career; participants also reported feeling more comfortable engaging in science communication after the workshop. Ultimately, we hope to utilize more classroom- and workshop-based activities to prepare better the next generation of scientists for science communication in a digital world.

**Funding Sources** This project was funded by an Undergraduate Research Experience grant from Fort Hays State University.

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Technical Session 7: Birds (Thursday, October 19, 2023, 8:00 AM)

## AVIALAN NESTING IN THE ARCTIC TRACES BACK TO THE CRETACEOUS

Wilson, Lauren N.[1], Ksepka, Daniel[2], Wilson, John[3], Brown, Caleb[4], Eberle, Jaelyn J.[5], Brinkman, Donald[4], Erickson, Gregory M.[6], Druckenmiller, Patrick S.[3]

[1]Department of Geosciences, University of Alaska Fairbanks, Fairbanks, Alaska, United States, [2]Bruce Museum, Greenwich, Connecticut, United States, [3]Museum of the North, University of Alaska Fairbanks, Fairbanks, Alaska, United States, [4]Royal Tyrrell Museum of Palaeontology, Drumheller, Alberta, Canada, [5]Museum of Natural History, University of Colorado, Boulder, Colorado, United States, [6]Department of Biological Science, Florida State University, Tallahassee, Florida, United States

Modern polar regions are critical breeding grounds for over 250 species of extant birds. Some travel to high latitudes gaining access to seasonally abundant resources, whereas others have adapted to endure the harsh polar winters. The avialan fossil record spans 150 million years, yet evidence for high-latitude bird reproduction extends only to the Eocene La Meseta Formation of Antarctica (56-33.6 Ma). Here we report Cretaceous perinate bird fossils from the paleo-Arctic Prince Creek Formation (PCF) of northern Alaska, extending the known record of high-latitude bird reproduction and demonstrating the first record of high-latitude bird reproduction in the Mesozoic. The PCF was deposited at 80-85°N paleolatitude, where continuous winter darkness would have lasted for up to four months and preserves an ancient polar ecosystem including avialan and non-avialan dinosaurs, mammals, and bony fish. Terrestrial ectotherms, such as crocodilians, turtles, and lizards are notably absent from the fauna, despite being abundant fossils at coeval mid-latitude localities. The new avialan material was found as part of a decade-long microfossil analysis of channel lag deposits. Developmental stage was assessed by small size and immature, long-grained bone texture. These perinate bird fossils have been found from three localities and consist of nine distal tarsometatarsi, two paired and fused premaxillae, one omal coracoid, and two distal humeri. Notably, these finds also represent one of the northernmost recorded cases of avialan reproduction, matched today only by a seabird colony off the coast of Greenland (83'38°N). This is the oldest direct evidence for Arctic bird reproduction and demonstrates that multi-taxic bird nesting has occurred in the High Arctic for at least 73 million years (late Campanian)—nearly half the tenure for which birds have existed on Earth. Likewise, these new fossils demonstrate that this behavior originated in the Mesozoic ancestors of Neornithes, millions of years before the radiation of crown group birds following the end-Cretaceous mass extinction.

**Funding Sources** National Science Foundation EAR 1226730 and EAR 1736515

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Virtual Posters

## PROCEDURE FOR THE DOCUMENTATION OF PALEONTOLOGICAL LOCALITIES AT BADLANDS NATIONAL PARK, INTERIOR, SOUTH DAKOTA

Wilson, Patrick J.

Badlands National Park, Interior, South Dakota, United States

Badlands National Park is approximately 244,000 acres and is one of the most fossiliferous units in the National Park Service. The park's White River Group sediments represent the Eocene/Oligocene transition and the Oligocene aridification of the northern Great Plains in North America. Badlands National Park has been actively documenting fossil localities since 1993, including historical localities dating back to the 1800s. Most of the recently documented localities were discovered through resource inventory projects, Visitor Site Reports, and pre-construction surveys. An average of 10 new localities are documented annually. To date, 345 localities have been documented within the park's legislative boundary.

Through the iterative process of documentation, Badlands National Park staff have refined their techniques for documenting the geographic area, stratigraphic position, taxonomic diversity, and relative abundance of taxa at paleontological localities. After finding a fossil-rich area, each

identifiable fossil is marked using survey marker flags. These flags are color coded according to the taxonomic type of the identified fossil. Once the identifiable fossils have been flagged for a given fossil-bearing area, photographs are taken, and a GIS feature class is created using ESRI FieldMaps to denote the geospatial extent and position of the location. The stratigraphic position is recorded, and a stratigraphic column is created from a geologic section of the area. A standardized locality worksheet and a condition evaluation form are completed after the geographic and stratigraphic contexts are determined. Once the paperwork is completed and the geographic and stratigraphic data are recorded, the scientifically significant fossils are pinpointed, recorded, tallied according to their taxonomic type, and collected using standard collection protocols. The remaining fossils identified by the survey flags are then tallied by the field technicians as the flags are removed. This tally represents the relative abundance of taxa at the site. Upon returning from the field, the site photographs are stitched together and labeled to denote the area and the significant fossils found at the site. A map of the locality is generated with the GIS data and the information from the locality worksheet is recorded into the park's Paleontological Locality Database. Any collected fossils are delivered to the seasonal preparation lab for cataloguing, conservation, and curation.

**Funding Sources** I want to acknowledge Badlands National Park and Badlands Natural History Association for funding resource inventory projects and seasonal internships, respectively.

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Technical Session 5: Ungulates (Wednesday, October 18, 2023, 1:45 PM)

**USING BAYESIAN MULTI-LEVEL MODELING TO PREDICT HABITAT IMPORTANCE IN RUMINANTIA**

Wimberly, Alexa

Organismal Biology and Anatomy, University of Chicago, Chicago, Illinois, United States

Identifying the form-function relationships that exist in extant species is crucial for inferring the ecology and evolution of extinct taxa. However, studies seeking to predict habitat use from morphological traits typically use discrete categories, which may be effective for statistical analyses but fail to account for the multivariate nature of the environmental contexts in which mammals exist. Here, I employ Bayesian multi-level modeling and rank the importance of 8 different habitat types for 208 living ruminant artiodactyls based on IUCN Redlist data. I use two functional indices from the hindlimb to develop a predictive model of habitat importance: the calcaneal gear ratio indicative of in-lever mechanics of the hindlimb and metatarsal/femur (MT/F) ratio as an index of cursoriality. Results show that differences in gear ratio did not strongly predict habitat importance. However, MT/F ratio strongly predicted preference for forest and savanna habitats, with a high probability of forest-dwelling species having a lower MT/F ratio (short metatarsus to femur length) and the opposite for taxa that inhabit savannas. These results suggest that more nuanced prediction of habitat use in extinct ruminants is possible.

**Funding Sources** Field Museum of Natural History Women in Science Graduate Fellowship

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**NEW RECORDS AND INTERPRETATIONS OF THE LATE-CENOZOIC PALEOCOMMUNITY OF THE HAILE 22A SITE OF ALACHUA COUNTY, FLORIDA**

Woodruff, Aaron, Walton, Chloe

vertebrate paleontology, University of Florida, Gainesville, Florida, United States

Haile 22A is one of the numerous karst deposits located in the unincorporated community of Haile in Alachua County, Florida located west of Gainesville and northeast of Newberry. Intermittently excavated from 1983 to 1984 during the excavation of larger pits nearby, the locality is unusual compared to other Haile sites in that larger mammals are relatively scarce and often represented by incomplete material. The microvertebrate fauna, however, is notably diverse and well-preserved. Despite this, the majority of the fossils have remained unidentified and uncatalogued since their initial collection 40 years ago, potentially leaving a substantial gap in our understanding of the natural history of the paleontologically significant Haile region. The microfauna is of particular interest for their value as temporal and environmental indicators.

In the present study, we report a complete faunal assemblage for Haile 22A with at least 42 identified taxa; 9 amphibian, 21 reptile, 2 bird, and 10 mammal genera. The presence of the pampathere *Holmesina floridanus*, as well as the rodents *Geomys pinetus* and *Sigmodon libitinus* suggests an early Irivingtonian (Ir1) age for the site, making it slightly younger than the more extensively excavated and documented Haile 7 site which has been dated to late Blancan (Bl2). Overall, many of the taxa present at Haile 22A are indicative of a moist woodland environment with substantial leaf litter and sandy, well-drained soils. Terrestrial taxa dominate the locality. Aquatic taxa such as turtles, alligators, fish, and certain salamanders (Sirenidae) being much less abundant than in older Haile sites, indicating that the area would have experienced occasional flooding from a nearby water source to facilitate the dispersal of such animals. This research helps to improve our understanding of the greater Haile region, which appears to have experienced a transition from a lake-dominated environment to a drier subtropical forest habitat from the Pliocene and into the Pleistocene.

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Romer Prize Session (Thursday, October 19, 2023, 8:00 AM)

**NOVEL APPROACHES TO EVALUATING THE QUALITY OF THE GLOBAL FOSSIL RECORD: THE FRONTIER BETWEEN TAPHONOMY AND PHYLOGENETICS**

Woolley, Charles H.

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Since Darwin's time, scientists have lamented the incompleteness of the fossil record, and much work has been devoted to characterizing patterns of fossil record bias. However, less attention has been paid to whether the phylogenetic information retained in fossils is also systematically biased in some way. In essence, we need to address not just what an imperfect/incomplete fossil record looks like, but also whether it can be trusted within a phylogenetic framework. Here, I present a phylogenetic approach that seeks to address three crucial questions in assessing the quality of the >242-million-year fossil record of squamates (e.g., lizards, snakes, amphisbaenians, and mosasaurs). Key Question 1: How does fossil incompleteness affect phylogenetic information content in the squamate fossil record? I use an established completeness metric to show that the average fossil squamate species preserves less than 20% of the total phylogenetic characters that can be scored. To test if this pattern is rooted in anatomical biases in the fossil record, I also use a large dataset of 6,585 specimens and 14,417 skeletal elements to show that marginal tooth-bearing bones and vertebrae are significantly overrepresented. Key Question 2: Does the incomplete skeletal representation in the squamate fossil record still retain reliable phylogenetic information? Using parsimony and model-based phylogenetic comparative methods, I show that the parts of the squamate skeleton most ubiquitously preserved in the fossil record retain the same level of phylogenetic signal as other parts of the skeleton that are rarer. These results imply that we can more confidently incorporate incomplete fossils into phylogenetic analyses. Key Question 3: What is the influence of lagerstätten on phylogenetic information content in the fossil record? Unexpectedly, the aeolian deposits of the Late Cretaceous Gobi Desert of Mongolia and China preserve an exceptionally complete and phylogenetically diverse lizard assemblage, such that it exerts anomalously high influence on the deep-time structure of squamate evolutionary relationships. These results offer a novel, phylogenetic lens on characterizing the macroevolutionary effects of lagerstätten in the fossil record. In sum, this work at a critical but largely ignored intersection of paleobiological inquiry provides fresh insight on age-old patterns of bias in the fossil record, while laying the foundation for future integrative and comparative studies.

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

**HEMPHILLIAN GRASSLAND ECOSYSTEMS: REVISITING DATA FROM THE MINIUM QUARRY (OGALLALA FORMATION) IN GRAHAM COUNTY, KANSAS**

Wooten, Brynn B.

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The Minium Quarry, a Hemphillian site located in Graham County, Kansas, has provided an unexpectedly thorough glimpse into the paleoecology and paleoenvironment of Kansas 6-7 MYA. Previous taphonomic and sedimentological research proposed that the Minium Quarry was a fluvial system, although it was unclear whether deposition occurred on a floodplain, in a channel lag, or in a point bar.

Due to varying preservation among weathering, scavenging, and disarticulation stages, past studies indicate that some fossils were buried quickly, while others were buried years after death. Lack of cross-bedding also indicates trampling after deposition. However, little research has been conducted on the site's vertebrate fossils since the 1990s, with almost no investigation of non-mammalian clades. The purpose of this study is to document patterns in vertebrate fossil accumulation, bone density distribution, and non-mammalian biodiversity to better understand the depositional environment and paleoecology of the site. Three-dimensional taphonomic data were collected in the field but had not yet been analyzed. Therefore, this study examined bone density distribution of Minium fossils to clarify the nature of the deposition and paleoenvironment of the site. The clade and number of bones per meter-square were mapped, illustrating bone density distribution and biodiversity. Using the density maps, an area of particularly high accumulation and biodiversity was identified, along with evidence of distinct depositional horizons. This is interpreted as the deepest point in the fluvial system with multiple depositional events. Previous taphonomic and sedimentological data, combined with newly analyzed fossil distribution data, supports a combination of channel and floodplain environments in an ephemeral fluvial system with wet and dry pulses. The area of high accumulation and biodiversity, the vast number of specimens, evidence of mixed burial rates, similarities to savanna ecosystems, fining-upward sequences, and trampling after deposition all support an ephemeral fluvial hypothesis. This more detailed depositional history of the Minium Quarry, along with taxonomic revisions, more accurately reconstructs the Hemphillian grassland ecosystems of Kansas. Now that quarrying has resumed at Minium, the density distribution and biodiversity maps can help researchers focus collecting efforts to recover the highest biodiversity represented.

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Technical Session 12: Methods & Paleohistology (Friday, October 20, 2023, 8:00 AM)

**RETRODEFORMATION OF OSTEOHISTOLOGICAL THIN-SECTIONS**

Wosik, Mateusz

Biology, Misericordia University, Dallas, Pennsylvania, United States

Histological thin-sectioning of specimens has become an imperative tool among paleontological studies because it provides individual age and growth data otherwise unobtainable from superficial morphological analyses. However, fossil specimens are often distorted due to taphonomic processes and may result in crushing and flattening. This distortion is typically reflected in these specimens upon histologically sectioning, potentially limiting or skewing the desired data.

Retrodeformation, which is the process of digitally reconstructing a specimen, was performed on histological thin-sections to test whether it would better recover a more accurate size and shape of the cross-sectional samples. This is an important step that is often overlooked when determining whether gaps along the circumference are indeed due to missing pieces of bone and/or a result of distortion from taphonomic processes, particularly in the case of lateral compression. The degree to which this process was required was dependent on the level of preservation of each specimen.

Results indicated significant quantitative differences when comparing the outer circumference and growth mark tracings in thin-sections of long bones that were retrodeformed versus the original images. When incorporated into a growth modeling analysis, data obtained prior to retrodeformation produced inflated growth trajectories relative to non-distorted specimens from the same bonebed sample. In comparison, data obtained after retrodeformation produced growth trajectories similar to those of the non-distorted specimens. It is therefore strongly encouraged to adopt retrodeformation as a normal practice to increase the consistency of interpretations among researchers and potentially increase the accuracy of the data being presented in published work.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**REBECCA'S HOLLOW: A FRESHWATER MICROVERTEBRATE ASSEMBLAGE FROM THE UPPER CRETACEOUS (EDMONTONIAN) WILLIAMS FORK FORMATION, NORTHWESTERN COLORADO, USA**

Wurtz, Alyssa L.[1], Crothers, Joel P.[1], Dunn, Renee[1], Carter, Caedan[1], Heckert, Andrew B.[1], Foster, John R.[1], Hunt-Foster, ReBecca K.[2], Eberle, Jaelyn J.[3]

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The Edmontonian is a North American land mammal age that is understudied especially when compared to the younger Lancian or older Judithian. ReBecca's Hollow is a freshwater microvertebrate fossil site in the lower half of the Williams Fork Formation (WFF; part of the Mesa Verde Group) in northwestern Colorado. Surface collections conducted initially at ReBecca's Hollow yielded predominantly cm-scale shell fragments of trionychid turtles and lepisosteid (gar) scales, but included several other taxa represented by fragments, leading to further investigation of the site and collection of sediments for processing. Screenwashing has resulted in the recovery of several thousand more mm-scale specimens. The ReBecca's Hollow assemblage thus far includes osteichthyans (bony fish), lissamphibians, lizards, turtles, crocodiles, choristoderes, dinosaurs, mammals, and a possible bird. Osteichthyans are represented by numerous scales, vertebrae, gar teeth, amiid teeth, pycnodont teeth, and phyllodont teeth (*Paralbula casei)*. Lissamphibians include 3 jaw elements possibly belonging to the families Sirenidae and Batrachosauroididae indet. Reptiles include turtles, lizards, crocodilians, choristoderes, and dinosaurs. The majority of turtle osteoderms belong to an indeterminate trionychid, most of the others we refer to *Adocus* sp. Lizards are identified by possible osteoderms and a single possible teiid jaw element. Crocodilians are represented by osteoderms, vertebrae, skull fragments, and many teeth, some of which are robust (durophagous) and considered aff. *Brachychampsa* sp. A single fragmentary tooth probably pertains to the choristodere *Champsaurus* sp. There are ornithischian and theropod dinosaurs identified from teeth. This includes a basal ornithopod, hadrosaurs, ceratopsians, dromaeosaurids, tyrannosaurids, and troodontids. A weakly denticulated tooth may pertain to an early avian. Mammals are represented by an upper right molar of *Alphadon* sp. and two multituberculate premolar tooth fragments. The lissamphibians and smaller theropods may, with more complete fossils, represent new records for the WFF. The ReBecca's Hollow site is a mudstone-hosted assemblage that lacks chondrichthyans, which are known from the WFF and are a common component of the J&M site, a nearby conglomerate-sandstone channel deposit. We interpret ReBecca's Hollow as a floodplain deposit based on the occurrence of the fossils in a drab mudstone with some pedogenic nodules.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**MODERN SPATIAL DIVERSITY, DISPARITY, AND TURNOVER IN THE HETEROMYIDAE (RODENTIA)**

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The Heteromyidae (pocket mice, kangaroo rats, and relatives) are a group of extant and extinct rodents that are abundant in North American fossil assemblages spanning the last 30 million years. Heteromyid species today are mostly desert-adapted and have a spatial peak in species richness in the desert ecosystems of the Basin and Range Province. However, the temporal peak of species richness for the Heteromyidae was during the Middle Miocene when there was an increase in both temperature and the rate of mountain building in western North America, not during the formation of desert ecosystems in the Plio-Pleistocene. The temporal disconnect between the geologic history of deserts and the fossil record of heteromyid species richness raises the question: what landscape or climate drivers might be influencing diversity in the Heteromyidae? This study investigates multiple axes of modern biodiversity including species richness, trait disparity, and turnover in species and traits across space. We assess traits using a 2D geometric morphometric dataset of heteromyid skulls. The morphometric landmarking scheme captures aspects of morphology that are correlated to ecological function and discriminate genera in the family. Our analyses use a spatially-unified dataset of species ranges and morphometric data. The results show species richness and trait disparity are positively correlated across space, but not linearly related as expected. Trait disparity increases to a point, and then plateaus as species richness continues to increase, with no significant difference in disparity for spatial grid cells with 5 or more species present, suggesting there is trait redundancy at local scales. The results of this study suggest the spatial processes governing species richness may be separate from the processes governing trait disparity in the Heteromyidae. The distinct patterns across diverse habitats today suggest richness and disparity are spatially decoupled in the Heteromyidae. Our results could have major implications for understanding the drivers of trait evolution and speciation in the Heteromyidae fossil record, especially as it relates to the history of landscape change.

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Technical Session 16: Theropods - I (Saturday, October 21, 2023, 8:00 AM)

**TOOTH USE AND WEAR IN CARNIVOROUS REPTILES, AND IMPLICATIONS FOR TYRANNOSAURID FEEDING BEHAVIOR**

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Macrowear refers to tooth abrasion visible to the naked eye, produced by tooth-tooth and/or tooth-food contact. Analysis of observed macrowear patterns can thus provide information regarding jaw mechanics, diet, and feeding behavior. Tyrannosaurid macrowear research has been limited to examination of isolated teeth from the upper Campanian of Alberta, but we conducted a broader survey of macrowear on in-situ tyrannosaurid teeth from the Late Cretaceous of North America and made direct comparisons with modern carnivorous reptiles. We subdivided the basic macrowear categories used previously, and documented macrowear distribution with respect to taxonomy, tooth position and the tooth surface(s) on which wear was observed. Macrowear was separated into three categories: facets (smooth, flat, typically oval surfaces with or without fine-scale scratches), spalling (removal of enamel with minor modification of overall tooth shape) and breakage (major modification of overall tooth shape with subsequent smoothing/wear). Facets were restricted to labial and lingual tooth surfaces but spalling and breakage occurred on other surfaces as well. To evaluate the influence on macrowear distribution of the variables considered in our study, we ran a series of AIC analyses. Family-level identification and the presence of labial facets, mesial spalling, mesial breakage and labial breakage emerged as the most important variables in our macrowear model. We then plotted the proportions of wear types relative to the number of teeth sampled to visualize distributions. Fewer than 15% of the teeth of any group exhibited labial facets. Varanids are characterized by a high degree of mesial spalling and a low degree of mesial breakage, and most crocodylians by the reverse; macrowear of any kind was rare in gavialids. Tyrannosaurid teeth show high levels of both mesial spalling and mesial breakage. Varanid teeth may be prone to spalling on the mesial carinae as forces generated by feeding would gradually transition from the tip to the mesial edge as the tooth became positioned more horizontally relative to the bone and was drawn distally through flesh, whereas in crocodylians forces are applied at oblique angles as chunks of flesh are ripped off during shaking and death rolling, making the leading edges of the teeth more prone to breakage. Tyrannosaurid wear patterns suggest flesh was penetrated in a tip-to-mesial fashion but the head was then twisted to rip off chunks of tissue.

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Technical Session 3: Fishes & Amphibians (Wednesday, October 18, 2023, 8:00 AM)

**DESCRIPTION OF A NEW SPECIES OF PANTYLID “MICROSAUR” FROM THE CARBONIFEROUS OF NOVA SCOTIA AND IMPLICATIONS FOR ITS ECOLOGY**

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“Microsaurs” are a group of terrestrial tetrapods that have been found at several localities in North America and Europe, ranging in age from the Late Carboniferous to the Early Permian. For decades, “microsaurs” were thought to be a monophyletic group within the non-amniote group Lepospondyli. Later studies have questioned the monophyly of Microsauria, and recent studies have even recovered recumbirostran “microsaurs” as early reptiles. The now polyphyletic status of “microsaurs”, wherein some members are considered amniotes and others remain unrevised alongside “lepospondyls”, indicates the need for further research on the anatomy of the group in order to better understand their relationships. Recently, a nearly complete skull of a recumbirostran “microsaur” was discovered in the Carboniferous Sydney Mines Formation of Cape Breton Island, Nova Scotia, Canada. The specimen reveals a large, broad, heavily sculptured, and stoutly built skull. Orientation patch count rotated (OPCR)

analysis of the marginal dentition indicates insectivory. However, micro-CT scans reveal extensive, opposing coronoid-palatal dental batteries hypothesized as an adaptation to high-fiber herbivory. The adductor chamber is also very large, consistent with housing the strong adductor jaw musculature required for such a diet. Therefore, the new taxon was likely an herbivore, potentially with some omnivorous feeding habits. Together with the absence of an ectopterygoid and the presence of polygonal dermal scales, the new taxon is similar to the Permian "microsaur" *Pantylus cordatus*. Preliminary phylogenetic analysis supports this relationship, revealing a sister-taxon relationship with *Pantylus cordatus*, making the new taxon a new addition to the Pantylidae. Together with *Stegotretus agyrus* from the Cutler Formation in New Mexico, the new specimen reveals the early diverging Pantylidae is broadly characterized by specialized dental and cranial morphology suited for herbivory or durophagy. This likely indicates Pantylidae was the earliest tetrapod lineage to experiment with complex dietary specializations such as herbivory, potentially as early as the middle Carboniferous.

**Funding Sources** Natural Sciences and Engineering Research Council of Canada, Carleton University

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

### DOES SCALE MATTER? CONSERVED EVOLUTIONARY ALLOMETRIES ACROSS DIVERSE *ANOLIS* LIZARD ECOMORPHS

Xu, Tianyi, Kemp, Melissa

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*Anolis* lizards are a renowned system in ecological and evolutionary studies due to their remarkable diversity arising from adaptive radiation. Across the Greater Antilles, anoles have convergently evolved into six habitat specialist groups, known as ecomorphs. While each ecomorph class is morphologically distinct, it is unclear if the different ecomorph classes also have distinct allometric scaling relationships between body size and morphological characters in response to selective pressures associated with habitats, or if such relationships are highly conserved across the radiation. To address this question, we measured 27 skeletal characters on specimens of known body size in 62 species of *Anolis* and characterized evolutionary allometries across ecomorph classes and the entire genus. While we found that ecomorphs had distinctly scaled morphological traits represented by different linear regression intercepts, a relatively conserved evolutionary allometric pattern was observed based on consistent slopes across ecomorphs, suggesting low evolvability of evolutionary allometric slopes. These consistent slopes also indicate that body size of anole fossils can be reconstructed using genus-level estimation equations, even without species-level taxonomic identification or information on ecomorphology. In summary, this study sheds light on patterns in allometric scaling relationships under convergent evolution and provides a useful tool for future paleobiological studies on body size evolution in anoles through time.

**Funding Sources** This research was funded by the graduate research grant at the Department of Integrative Biology, The University of Texas at Austin.

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Regular Poster Session 1 (Wednesday, October 18, 2023, 4:30 - 6:30 PM)

### EARLY PLIOCENE MICE AND RATS FROM THE GRAY FOSSIL SITE OF EASTERN TENNESSEE

Xu, Ziqi, Samuels, Joshua X.

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Cricetidae includes a wide range of mice and rats and is the second-most species rich and abundant family of mammals. While currently distributed across the Americas and Eurasia and known from many fossil sites across the continent, few records have been studied from eastern North America prior to the Pleistocene. This study describes the assemblage of cricetid species from the Gray Fossil Site (GFS) of Tennessee, an early Pliocene site well-known for preserving diverse fauna and flora. While the occurrence of cricetids has been previously noted at GFS, this study provides a detailed description of seven cricetid species and improves understanding of small mammals from the site. Specimens were examined under stereomicroscope and DinoLite digital microscope camera, allowing qualitative assessment of occlusal morphology and quantitative comparison to modern cricetids and published fossil records from across North America. The fauna includes: two *Peromyscus* species, *Postcopemys*, *Symmetrodontomys*, *Neotoma*, *Repomys*, and *Neotomodon*. The most common taxa at the site are the deer mouse *Peromyscus*, which is currently the most abundant and widely distributed mammal in North America, and the woodrat *Neotoma*. The record of *Neotomodon* represents the first outside of Mexico and only prior to the late Pleistocene. While the GFS specimens can be categorized into known genera, distinctive morphological features suggest the presence of some new species. The Pliocene cricetid assemblage at GFS exhibits diverse body sizes and dietary preferences (based on crown-heights) and is distinctly different from other contemporaneous sites, emphasizing the spatial and temporal uniqueness of the site. The Appalachian region represents a biodiversity hotspot today, and GFS was likely an important habitat for cricetid evolution during the Pliocene.

**Funding Sources** East Tennessee State University Master's Program

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

## DIETARY VARIABILITY IN *LYNX RUFUS* FROM THE PLEISTOCENE TO THE PRESENT

XU, Chuyuan, Wei, Jialei, DeSantis, Larisa

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Predators' prey selection is largely influenced by their geographic ranges and evolutionary history. Extant bobcat (*Lynx rufus*) distributions extend from southern Canada to central Mexico, nearly covering all twelve Level I ecoregions (e.g., temperate forests, deserts, great plains, etc.). Most previous research reports bobcats as generalized foragers in the north but more specialized in the south. This study aims to assess the feeding behavior of *Lynx rufus* throughout their range and time and if and how dietary variability correlated with biomes. These data are critical for establishing a baseline of extant bobcats, enabling comparisons of bobcat diets across space and since the Pleistocene. Bobcats spanning from the 1890s to the Present were examined, including cats from Eastern Temperate Forests, Northern Forests, Northern Mountain Forests, Great Plains, Mediterranean California, Deserts, etc. We find that dental patterns in these ecoregions do not significantly differ from each other, with indistinguishable mean values for *Asfc* and *epLsar* metrics ($p>0.05$). Microwear attributes also do not show significant differences between males and females or across time, though DMTA complexity values are significantly higher in the Present as compared to during the Pleistocene (when compared to *Lynx rufus* from Rancho La Brea, n=11). In summary, these results indicate that bobcat diets are today more generalized than at Rancho La Brea and that this dietary variability is prevalent in most ecoregions today. Understanding the dietary behavior of bobcats is crucial to bobcats' conservation, especially if their realized niche has changed over time.

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

## EVALUATION OF THE AERODYNAMIC PERFORMANCE OF *ANCHIORNIS HUXLEY* USING ITS HINDLIMBS AS WINGS

Yamazaki, Yusuke[1], Inada, Yoshinobu[2], Kakuta, Kazuhiko[3]

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*Anchiornis huxley* is a paravian dinosaur that lived in China about 160 million years ago. They had wings not only on their forelimbs but also on their hindlimbs. Therefore, they may have glided with both fore and hindlimbs. Since the 20th century, there has been a theory that the ancestors of birds had wings on their four limbs. Therefore, investigating the aerodynamic performance of such dinosaurs is expected to provide important insight into the origin and evolution of bird flight. Such studies have often been done on *Microraptor gui*, but not *Anchiornis*. The main wing of *Anchiornis* on their forelimbs was relatively smaller than in *Microraptor* and modern birds of similar size. If their hindlimbs are used as hind wings, they may obtain greater lift. In this study, we constructed a life-size model and conducted a wind tunnel test to investigate their flight performance.

In the wind tunnel test, the model has placed different postures: the legs hanging down under the body ("legs down") and the legs spread out almost to the side of the body ("legs sprawled"). "Legs sprawled" individuals were placed into three different postures: stretched knees, knees bent backwards by 30 degrees, and knees bent backwards by 60 degrees. We measured lift and drag and compared the lift-to-drag ratio of each posture.

As a result, "legs sprawled" had a slightly higher lift-to-drag ratio than "legs down" regardless of the knee bending angles. It was also found that the lift-to-drag ratio of stretched knees is higher than that of bended knees. This may be because the aspect ratio of bended knees becomes lower than that of stretched knees. However, the lift-to-drag ratio is small, and thus *Anchiornis* could not glide over a long distances. This may be because the distance between the main wing and the hind wing with stretched knees is small compared to bended knees and the hind wing suffers from the downwash of the main wing degrading its aerodynamic performance.

These results indicate that the use of hindlimbs as the hind wing is not necessarily effective for high lift-to-drag ratio although it can contribute to expanding the wing area to increase lift. Bending and stretching of the knees of hindlimbs have both positive and negative effects on flight performance. Such noncommittal features may be related to the evolutionary disappearance of the hind wing and the development of a single main wing with large area and large aspect ratio in birds.

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Technical Session 17: Afrotheria & Mammal Macroevolution (Saturday, October 21, 2023, 8:00 AM)

**A NEW MODEL OF STRONTIUM ISOTOPE TURNOVER PROVIDES QUANTITATIVE RECONSTRUCTIONS OF STRONTIUM INTAKE FOR PALEO-MIGRATION STUDIES OF PROBOSCIDEANS**

Yang, Deming[1], Bowen, Gabriel[1], Uno, Kevin[2], Podkovyroff, Katya[3], Carpenter, Nancy[4], Fernandez, Diego P.[1], Cerling, Thure E.[1]

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Strontium isotope ratios ($^{87}Sr/^{86}Sr$) of incrementally grown tissues have been widely used to study movement ecology and migration of both extant and extinct animals. However, the timescale of $^{87}Sr/^{86}Sr$ incorporation from the environment into tissue and how it may influence data interpretation are still poorly understood. Using the relocation of a zoo elephant (*Loxodonta africana*) named Misha, we characterized the $^{87}Sr/^{86}Sr$ turnover process using high-resolution measurements of tusk dentin and developed a quantitative model that helps to interpret $^{87}Sr/^{86}Sr$ data in hard tissues. We measured the $^{87}Sr/^{86}Sr$ transition associated with the elephant's relocation from California to Utah using laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) on a prepared ivory slab. We built the turnover model, with a rapidly-exchanging central pool and a slowly-exchanging peripheral pool, in a Bayesian statistical framework. We first used the measured tusk dentin and associated feed and water data to calibrate the model parameters. We then used the calibrated parameters to estimate possible $^{87}Sr/^{86}Sr$ intake time series from two ivory datasets: a fidelity test with Misha's tusk data and a case study with published $^{87}Sr/^{86}Sr$ measurements from the tusk of an Alaskan Woolly Mammoth (*Mammuthus primigenius*). The LA-ICP-MS data from Misha's tusk are consistent with a two-compartment turnover process with one fast and one slow turnover rate. The model inversion shows high fidelity when estimating the intake $^{87}Sr/^{86}Sr$ time series associated with Misha's relocation. In the Woolly Mammoth case study, the model suggests an abrupt pattern of change in, and a much wider range of, intake $^{87}Sr/^{86}Sr$ values than recorded in the tusk dentin. Our model bridges the gap between environmental $^{87}Sr/^{86}Sr$ variation and data measured in tusks or other incrementally grown tissues. It could be coupled with movement models and additional isotope tracers to study seasonal residency or the spatial and temporal patterns of movement/migration. The generic turnover processes can be adapted to other isotope systems, additional incremental tissues, or other organisms, thus expanding our modeling toolkit to investigate niche partitioning and life history traits in paleoecology.

**Funding Sources** NSF DBI-1565128 and DBI-1759730, EAR-0819611, BCS-0621542; University of Utah Graduate Research Fellowship; the Vetlesen Foundation (Columbia University).

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Technical Session 4: Dinosaur Soft Tissues (Wednesday, October 18, 2023, 1:45 PM)

### THREE-DIMENSIONAL PRESERVATION OF SKIN ULTRASTRUCTURE IN A FEATHERED DINOSAUR

Yang, Zixiao[1], Jiang, Baoyu[2], McNamara, Maria E.[1]

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Fossil feathers provide critical insights into feather evolution. The underlying skin, however, has received relatively little attention, limiting our understanding of the evolutionary transition from scaled to feathered skin in archosaurs. Here we investigate a new specimen of *Psittacosaurus* (Jehol Biota, China), a non-avian dinosaur known to preserve feathers on the tail and scales in other body regions. We identified patches of mineralized skin in the (non-feathered) torso using stereomicroscopy coupled with ultraviolet light. Scanning electron microscopy reveals that the fossil skin is replicated in silica in three dimensions and shows two distinct layers. The upper layer comprises ca. 10–20 sublayers, each ca.1.8–2.5 µm thick, that represent preserved corneocytes of the stratum corneum. The thinner lower layer lacks internal structure and represents the remains of the uncornified inner epidermis and possibly the upper dermis. The thickness of the *Psittacosaurus* stratum corneum is comparable to that in the scales of extant juvenile crocodiles, which are rich in tough corneous beta protein; it is also comparable to that in the ventral apterium of birds, which is made of soft keratin but is unexposed and physically shielded by adjacent feathers. Given the necessary need for mechanical protection, the stratum corneum of *Psittacosaurus* probably had a primary composition of corneous beta protein rather than keratin. Our study also reveals molds of microbodies, interpreted as melanosomes, that can occur in the uncornified inner epidermis or in both the cornified and uncornified layers. This anatomical distribution of melanosomes is consistent with that in crocodilian scales. Our findings confirm that the skin of *Psittacosaurus* retained the plesiomorphic condition of its scaled ancestors in non-feathered body regions. Deviation from this ancestral condition may have only occurred locally, in the feather tracts. Since feathers were probably sparse and localized to specific body regions during the early stages of their evolution, the retention of reptile-type skin in the rest of the body would have ensured critical skin functions such as mechanical protection, protection against dehydration and immunity; intriguingly, this could have promoted the retention of novel feather traits over time.

**Funding Sources** Government of Ireland Postdoctoral Fellowship, National Natural Science Foundation of China (41688103, 41672010) and Strategic Priority Research Program (XDB26000000)

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Paleontological Management Poster Session
(Wednesday, October 18, 2023, 4:30 - 6:30 PM)

### THE MAMMOTH IN THE ROOM: PALEONTOLOGICAL RESOURCES AND NON-FEDERAL PARTNERSHIPS AT WACO MAMMOTH NATIONAL MONUMENT

Yann, Lindsey T.

Waco Mammoth National Monument, National Park Service, Waco, Texas, United States

Waco Mammoth Site, first opened as a City of Waco (CoW) park in 2009, was designed to be a National Park Service (NPS) “park in a box.” A 2015 presidential proclamation created Waco Mammoth National Monument (WMNM) with the direction that four partners, NPS, CoW, Baylor University (BU), and Waco Mammoth Foundation (WMF), would work together to preserve the remains of a Columbian mammoth nursery herd and its co-occurring taxa, inspire visitors, and support research. The Monument’s authorized boundary included 108.5 acres; 4.93 acres being federally owned. At designation, the federal land encompassed all known paleontological resources, and the ownership of all excavated fossils was to be transferred to NPS. A General Agreement between NPS, CoW, and BU guides cooperative management to increase the understanding of the fossil resources and allow access for research and interpretation. Since hiring the first NPS paleontologist (2020), three new fossil localities that are contemporaneous with original excavations have been discovered on CoW-owned land. Each new discovery requires different management strategies, and existing agreements do not provide legal requirements for ownership or management. In addition to the new discoveries, the donation has been slowed by a complex history of unwritten agreements and unclear ownership. Under existing agreements, NPS can provide services to CoW in the form of research or resource

management, but ownership and protection of specimens remains with the landowner. While new agreements are in process, critical issues developed regarding new discoveries, the donation, and land ownership during establishment of the paleontological program. Existing agreements give federal personnel access to non-federal lands and open the door for collaboration, but they would benefit from additional specificity given ownership complexities. Improved agreements—or other strategies, such as land transfers—are critical to managing research, addressing resource damage, and documenting new discoveries. Future partnerships would benefit from developing more detailed strategies for both resource management and land ownership during early phase planning. Strategies may include agreements for future resources that directly address ownership, responsibilities, and best practices. A well-structured partnership that ensures primary resources are managed under a single set of regulations is critical to the long-term preservation of nonrenewable resources.

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Regular Poster Session 2 (Thursday, October 19, 2023, 4:30 - 6:30 PM)

**NEUROCRANIAL ANALYSIS OF AN EARLY DEVONIAN ARTHRODIRE PLACODERM SHEDS LIGHT ON EARLY GNATHOSTOME BRAIN EVOLUTION**

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Placoderms, a paraphyletic group of stem gnathostomes, represent basal jawed vertebrates from the Silurian to Devonian periods (~430-360 million years ago). Among these, arthrodire placoderms have been particularly important in elucidating in early gnathostomes (jawed vertebrates), given their abundance in assemblages worldwide. However, most placoderms are preserved with their dermal skeleton. The cartilaginous neurocranium, packed with anatomical details key for phylogenetic and functional inferences, is often not preserved. Here we present the new data of a complete skull of *Buchanosteus* (ANU V244), an arthrodire from the Early Devonian (Emsian) Taemas-Wee Jasper/Burrinjuck limestones of New South Wales, Australia. High resolution computed scanning (HRCT) of the specimen in 2015 reveals numerous anatomical details, including a complete, perichondrally ossified braincase, articulated rostral, optic capsules, jaws and cheek. Of particular interest is the preservation of the trigeminal complex in ANU V244, which exhibits an intact, well-developed distal bifurcation. The excellent preservation of the three-dimension morphology provides crucial insights into the issuing of the profundus canal and the course of maxillary and mandibular branches. A comparison with other arthrodires (e.g., *Tapinosteus*, *Kujdanowiaspis*), extant and fossil chondrichthyans allows a new understanding of the evolution of the trigeminal nerve in the early jawed vertebrates. Additionally, our study sheds light on serval other neurocranial character transitions from basal to crownward stem gnathostomes, including the presence of a single transverse pituitary vein as a primitive gnathostome condition, and the ventrally-projected hypophyseal duct resembling more nested gnathostomes.

**Funding Sources** Strategic Priority Research Program of Chinese Academy of Sciences (XDB26000000), National Science Fund for Excellent Young Scholars (42022011)

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Regular Poster Session 3 (Friday, October 20, 2023, 4:30 - 6:30 PM)

**USING EXTANT *LOXODONTA AFRICANA* AGE CORRELATIONS TO DESCRIBE AN EXTINCT *MAMMUTHUS COLUMBI* ASSEMBLAGE AND MORTALITY FROM WACO MAMMOTH NATIONAL MONUMENT (WACO, TEXAS)**

Yard, Maree M.[1], Yann, Lindsey T.[2], Forman, Steven[1]

[1]Geosciences, Baylor University, Waco, Texas, United States, [2]Waco Mammoth National Monument, Waco, Texas, United States

A *Loxodonta africana* age correlations between epiphyseal fusion and both dental stages and ontogenetic ages, reported in African Equivalent Years (AEY), was used to describe an extinct *Mammuthus columbi* assemblage from Waco Mammoth National Monument (WMNM, Waco, Texas) that has been OSL dated to ~66 ka. Descriptions include age at death, stature, and sex (when possible).

Articulated to semi-articulated specimens, stored at Baylor University Mayborn Museum, were previously separated into individuals A-Z. Disarticulated storm wash out material and fragmented specimens were examined for additional identifiable limb elements, and fragmented specimens were reconstructed when possible. The survey resulted in 10 complete long bones, 70 partial long bones, and 56 fragments that could be identified with an individual mammoth. The individuals were separated into three groups based on ontogenetic and dental stages: juvenile, prime adult, and older adult. Juvenile is classified as 0-19 AEY, with the presence of molars I-III or complete fusion of the pelvic acetabulum. Prime adults are classified as 20-59 AEY, with a combination of molars IV-V or long bone complete and partial fusion of the distal and proximal epiphysis to diaphysis. Older adults are classified as ≥ 60 AEY, with molar VI or complete long bone fusion of the distal and proximal epiphysis to diaphysis. The count of skeletal elements indicates a minimum number of 18 individuals, Mammoths A-E, G-P, S, T, and U. Measurements and analyses indicate the assemblage consists of 5 juveniles (27.5 %), 12 prime adults (66.5 %), and 1 older adult (6.0 %), ranging from ~ 1 to 70+ AEY.

The histogram and ternary binned ages are consistent with a catastrophic death assemblage with highest mortality in prime adults. A high percentage of prime adults and low percentage of juveniles suggests the assemblage may have been declining when compared to living populations of *L. africana*. The presence of only 2 young juveniles (~1- 4 AEY) may indicate unfavorable conditions such as floods, droughts, or diseases in central Texas ~66 ka ago. While determining biotic or environmental causes are beyond the scope of this project, the high percentage of prime individuals preserved at WMNM is intriguing and requires additional investigation. This large assemblage of adults and juveniles provides a rare opportunity to better understand *M. columbi* populations and the paleoecology of central Texas.

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Technical Session 12: Methods & Paleohistology (Friday, October 20, 2023, 8:00 AM)

**APPLY ARTIFICIAL INTELLIGENCE IN PALEONTOLOGY: HISTORY, PROGRESS, AND PERSPECTIVES**

Yu, Congyu[1], Qin, Zichuan[2]

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Recent progress in artificial intelligence (AI) and the accumulation of fossil data lead to the emergence of deep learning applications in paleontological research. We first review the history of AI applications in paleontology, from the early rise of expert system to the widely practice of convolutional neural networks, showing the improvements in datasets, methods, and performances and comparing with classic AI studies. The results indicate that there is a 10 to 20-year latency between paleontological and mainstream AI studies. Then, we provide two example deep learning applications in paleontology: segmentation of CT scan image from ceratopsian dinosaurs and segmentation of primary/secondary osteons from alvarezsaurian dinosaur bone thin sections. Deep learning not only significantly reduce data processing cost but offers benchmark for performance evaluation in similar tasks. On the basis of automated processed data, the developmental trajectories of these two groups of dinosaurs are analyzed. We found that peramorphosis plays a crucial in the development of ornamental structures in ceratopsian dinosaurs and pedomorphosis is essential for the miniaturization of alvarezsaurian dinosaurs, respectively. The importance of larger and more balanced datasets is discussed. Last, we introduce several fresh AI advancements such as one/few-shot learning and automated content generation based on stable diffusion and suggest their possible interactions with future paleontological studies.

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Technical Session 10: Euarchontoglires & Xenarthra (Friday, October 20, 2023, 8:00 AM)

**HOLE IN TWO: DESCRIBING THE BASIVERTEBRAL FORAMINA IN PILOSA**

Zack, E. Hartrich[1], Smith, Stephanie M.[2], Angielczyk, Kenneth D.[2]

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Sloth vertebrae possess two enlarged foramina on the ventral surface of the centrum. This character, the intrarachidian or basivertebral foramina, has not been examined in developmental, biomechanical, or functional contexts. Here, we describe this morphology and note patterns through the vertebral column, development, and between taxa. The foramina are present in all trunk vertebrae and occasionally the cranial sacrals in all sloths, including fossil taxa, and some anteaters. They lead into canals that traverse the centrum and exit at the dorsal foramina for the basivertebral veins, intrarachinian circulation, or intraspinal venous circulation, as described by de Burlet in 1920. We used Bayesian modelling to analyze how taxonomic group, ontogenetic stage, and vertebral position impacted the presence of the basivertebral foramina. All three variables impacted foramen presence and cranio-caudal length. The morphological patterns found in sloths and anteaters differ. In anteaters, the foramina presence differs between the three extant genera two of which almost never had basivertebral foramina. In the adults and juveniles of sloths, these foramina are largest in caudal thoracic and lumbar vertebra and smallest in cervicals, although they are relatively smaller throughout the vertebral column in juveniles. Among neonates, the foramina are comparatively large, spanning almost the entire cranio-caudal length of each centrum throughout the vertebral column. In some extant and fossil sloth specimens, only one foramen is present, typically on the left. This occurs more often in cervical vertebrae but occasionally in thoracics and lumbars as well. In *Bradypus* and *Pseudomegatherium*, the wall between the two foramina has been resorbed in some lumbar and thoracic vertebrae, creating a single, wider foramen. In all sloths and anteaters, these foramina are the least likely to be present in caudal vertebrae and most likely to be present in lumbars. Because all extant sloths are suspensory, some have hypothesized that the enlarged foramina are used for increased venous circulation required by their typical body position. However, this hypothesis seems unlikely due to the presence of enlarged foramina in all extinct sloths and some anteater none of which are suspensory.

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Virtual Posters

**A NEW SPECIES OF *SIMIDECTES* FROM THE EARLY UINTAN OF CALIFORNIA CLARIFIES THE AFFINITIES OF THE GENUS**

Zack, Shawn P.

Basic Medical Sciences, University of Arizona College of Medicine-Phoenix, Phoenix, Arizona, United States

*Simidectes* is an enigmatic carnivorous mammal known from the Uintan and Duchesnean (middle Eocene) of North America. The unusual, derived dental morphology of *Simidectes* has made assessment of its affinities difficult. A diversity of potential relationships have been considered, although recently reported postcranial remains support a relationship to Hyaenodonta. A new specimen of *Simidectes*, comprising a dentary with p3-m3 from the early Uintan Friars Formation of southern California is the earliest record of *Simidectes* from California and represents a new species. The dental morphology of the new species is less divergent than other *Simidectes*, offering new evidence of the affinities of the genus.

The new form is the smallest known species of *Simidectes*, 10 to 20 percent smaller than *S. medius* in linear measurements. Notable aspects of molar morphology include a paraconid portion of the paracristid is more salient than in other *Simidectes* and no development of a premetacristid connecting the paraconid and metaconid. The talonid has a low but well-defined rim, formed by a nearly continuous crest incorporating the entoconid and hypoconulid. The apex of the hypoconulid is close to the apex of the hypoconid, with a very short posthypocristid connecting them, and the entoconid is not clearly differentiated from the remainder of the entocristid.

The presence of salient, if short, molar paracristids suggests derivation of *Simidectes* from a more typically carnivorous mammal, with the unusual, non-shearing trigonid of more derived *Simidectes* species representing an apomorphic condition within the genus. Talonid morphology is particularly informative concerning the affinities of *Simidectes*. The structure of the talonid is similar to some hyaenodonts and “miacids” and contrasts with other groups with which *Simidectes* has been argued to have an affinity. This is particularly true of members of Pantolestidae, which have a broader talonid, better differentiated hypoconulid and entoconid, more separated hypoconid and hypoconulid with a longer posthypocristid, and a more lingually positioned entoconid. The dental morphology of the new species is consistent with postcranial evidence for a hyaenodont affinity, but it remains difficult to align *Simidectes* with more typical hyaenodonts, indicating a substantial undocumented history for the genus.

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Regular Poster Session 4 (Saturday, October 21, 2023, 4:30 - 6:30 PM)

**FOSSIL SALAMANDERS (AMPHIBIA, CAUDATA) FROM THE OLIGOCENE OF FLORIDA**

Zbinden, Samantha P.[1], Vallejo-Pareja, Maria C.[2], Bourque, Jason R.[3], Blackburn, David C.[4], Bloch, Jonathan I.[3]

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Vertebrate fossils from the Oligocene are among the oldest documented terrestrial faunas recovered in Florida, yet little is known about the salamanders (Caudata) from this interval in the eastern United States. To address this, we studied collections of three Oligocene karst fissure-fill localities from Florida: the I-75 site (early Oligocene, late Whitneyan or Arikareean 1, ~30 Ma), Brooksville 2 (late Oligocene, Arikareean 2, 27-25 Ma), and Live Oak SB-1A (late Oligocene, Arikareean 2, 25-23 MA). Comparisons of isolated fossil vertebrae with those of extant salamander families known in Florida and eastern North America were made using digital specimens generated from X-ray computed microtomography (μCT) of alcohol-preserved specimens, as well as disarticulated skeletons from the Division of Herpetology in the Florida Museum of Natural History (FLMNH). Among the 72 caudate fossils from these three localities, we identified representatives of the Ambystomatidae, Amphiumidae, Salamandridae and Sirenidae. The lowest diversity is from the I-75 and Live Oak SB-1A samples. At I-75 two families are present with a total of 23 trunk vertebrae; the Sirenidae, which represents 96% of the caudate fossils from this locality, and the Amphiumidae comprising 4% of the sample. At Live Oak SB-1A we identified 32 vertebrae, including 3 atlas and 29 trunk vertebrae. The Salamandridae comprises 97% of this caudate fauna and the Sirenidae 3%. From Brooksville 2, of 15 total identified trunk vertebrae we identified three families. The Sirenidae and Salamandridae are the most abundant (47% and 41%, respectively), and the Ambystomatidae comprises 12% of the sample. The salamandrid fossils compare well to the vertebrae of the extant newt *Notophthalmus* in morphology and body size. The sirenids represent small to mid-sized taxa for the family, much smaller than extant *Siren lacertina*. The ambystomatid, *Ambystoma sp.,* has stout-bodied vertebral proportions similar to those seen in *Ambystoma tigrinum* and *Ambystoma talpoideum*. This record is the second oldest occurrence of *Ambystoma*, the oldest from the late Eocene (Chadronian) of Saskatchewan. All fossils identified in this research represent the earliest occurrence of these salamander families in Florida.

**Funding Sources** NSF (DBI-1701714) to DCB and JIB, NSF (DBI-1756306) to JIB and DCB

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Technical Session 3: Fishes & Amphibians (Wednesday, October 18, 2023, 8:00 AM)

**A COMPLETELY PRESERVED EARLY SILURIAN BONY FISH REVEALS THE MOSAIC CHARACTER COMBINATION IN THE STEM-GROUP OSTEICHTHYAN**

Zhu, You-an[1], Lu, Jing[1], Ahlberg, Per[2], Zhu, Min[1]

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The osteichthyans, or bony fishes and their terrestrial descendants, have been highly successful both on land (tetrapods), and in water (actinopterygians) from at least mid-Devonian until today. However, the origin and the earliest diversification of osteichthyans remain obscure. While molecular evidence suggests that the split between osteichthyan and chondrichthyan lineages occurred in Late Ordovician, the earliest osteichthyan fossils are found in the Silurian, and are primarily composed of micro-remains. Near-complete, articulated osteichthyan fossils were only discovered a decade ago, in the late Silurian (Ludfordian, Ludlow, ~425 Ma) of Yunnan, South China. In contrast to the chondrichthyan lineage, which has an extensively recorded stem-group known as "acanthodians", osteichthyans lack a fossil record of an unequivocal stem-group. The early Silurian Chongqing Lagerstätte (late Telychian, Llandovery, ~436 Ma) and the slightly older micro-remain findings from Guizhou offer a unique opportunity to examine the morphology and diversity of early Silurian gnathostomes. A previous report on the Lagerstätte revealed a large number of placoderm fossils and a bizarre, armored chondrichthyan. Here, we report a completely preserved osteichthyan from the Chongqing Lagerstätte. The fish is tiny, with a

total body length of approximately 3 cm, and is represented by two articulated specimens, including a completely one that reveals the morphology from head to tail. The skull roof is longitudinally divided into two parts, similar to that of the sarcopterygians and the late Silurian *Guiyu oneiros*. The roofing median dorsal plates or scutes are much more extensively developed than those in *Guiyu*. The cheek complex and the single, posteriorly placed dorsal fin are actinopterygian-like. Strikingly, the new fish exhibits an anal fin spine, previously thought to be exclusive to “acanthodians”. The upper marginal jaw bone, reconstructed from the tomographic data of the second specimen, displays multiple rows of dentition, similar to the previously reported isolated Silurian osteichthyan jaw element. This contrasts with the monolinear marginal dentition found in crown-group osteichthyans. Phylogenetic analyses resolved the new osteichthyan into the stem-group, suggesting that the character combination displayed by the new taxa may be ancestral in osteichthyan lineage, before the split of two major groups.

**Funding Sources** This study is funded by National Natural Science Foundation of China (42272028), and one hundred talents project from the Chinese Academy Sciences (E0CQ010103).

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2019-2022 Jon C. Graff Awardees

**BIOSTRATIGRAPHIC CORRELATION OF UPPER KAROO-AGE FOSSILS FROM THE MPANDI FORMATION OF SENTINEL RANCH, TULI BASIN, ZIMBABWE**

Zondo, Michel[1], Choiniere, Jonah[2], Barrett, Paul[3]

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The Mpandi Formation is the sole upper Karoo aged fossiferous unit in theTuli Basin of Zimbabwe and based on the co-occurrence of the early branching sauropodomorph dinosaur genus *Massospondylus*, it is correlated with the Elliot Formation of South Africa. Previous Mpandi palaeontological fieldwork also identified the presence of the wastebasket sauropodomorph taxon "*Euskelosaurus*." In the traditional upper- Karoo biozonation, the "*Euskelosaurus*" Assemblage Zone was considered to be Upper Triassic, and the *Massospondylus* biozone was considered to be Lower Jurassic, a result generally upheld by recent reassessment, which suggests these biozones are up to 20 million years apart from each other. This suggests that the Mpandi Formation, despite only presenting a few tens of meters of outcrop thickness, may contain Elliot Formation correlatable beds that span the Triassic-Jurassic boundary, but this has only been tested in a preliminary fashion. My working group at the Natural History Museum of Zimbabwe has been conducting ongoing fieldwork at the Sentinel Ranch locality aimed at improving our knowledge of Mpandi vertebrates. Among the findings of this work are several dinosaur fossils bearing autapomorphic features that allow identification to relatively low taxonomic levels, including cf. *Melanorosaurus*, cf. *Pulanesaura*, and cf. *Massospondylus*. The identities of these new specimens enable higher- precision correlation with the better studied strata of the Main Karoo Basin and suggest that, although relatively thin, the Mpandi has a temporal span extending from the middle part of the lower Elliot Formation to at least the lower part of the upper Elliot Formation. This may indicate a cryptic unconformity within the Mpandi Formation, its diachronous deposition due to faulting, or the co-occurrence of taxa that are separated by millions of years in the main Karoo Basin.