



82ND ANNUAL MEETING

SVP 2022 Program Guide

*The Westin Harbour Castle • Toronto, Ontario, Canada
November 2 - 5, 2022*



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82ND ANNUAL MEETING

November 2022 Abstracts of Papers



**THE WESTIN HARBOUR CASTLE • TORONTO, ONTARIO, CANADA
NOVEMBER 2-5, 2022**

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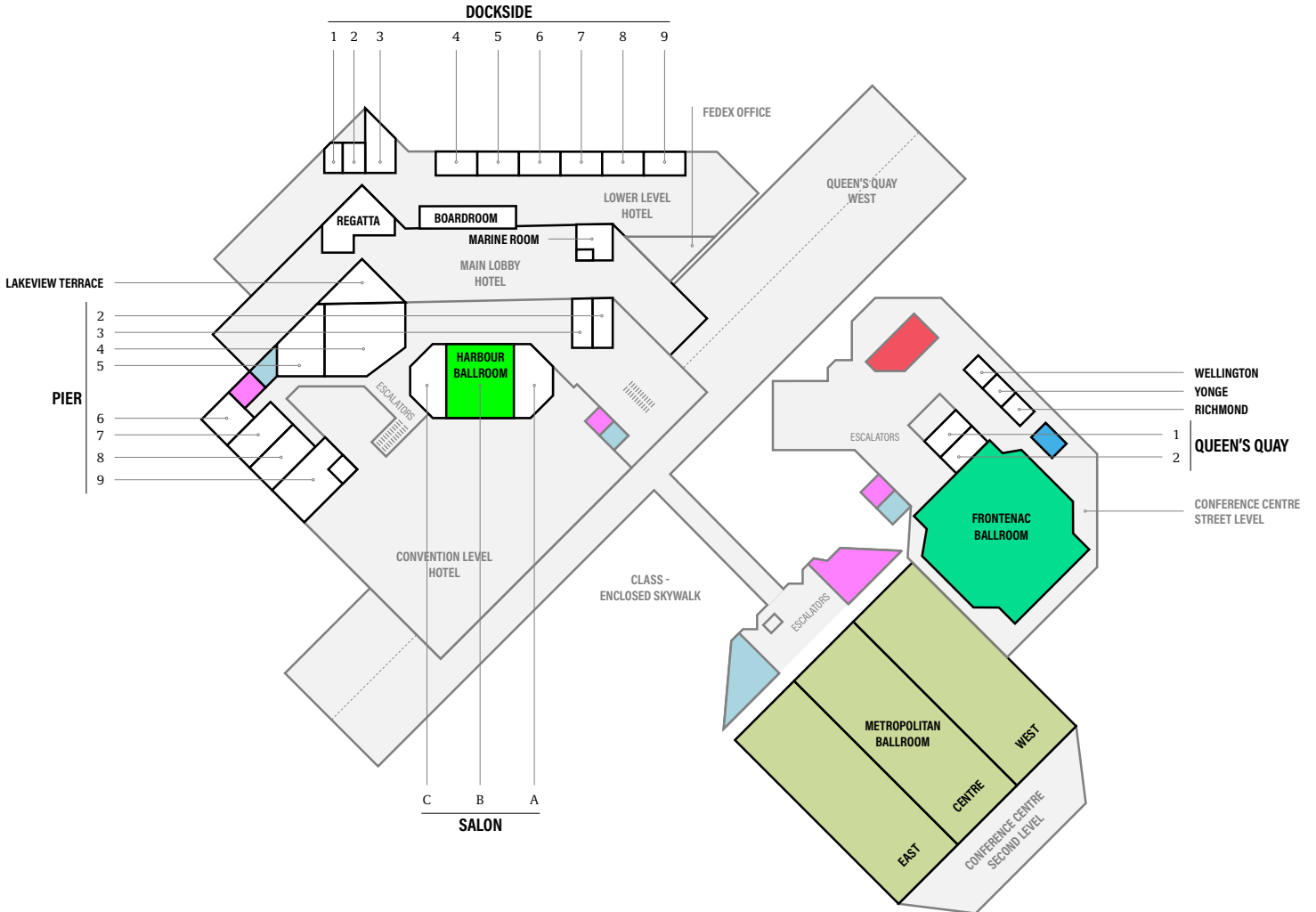
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Dana J. Ehret, Andrew A. Farke, Ethan Fulwood

THE WESTIN HARBOUR CASTLE • FLOOR PLAN



- AUCTION EVENT
- REGISTRATION DESK
- FOYER SPACE - POSTER MEET & GREET
- POSTERS & EXHIBITS
- 3 CONCURRENT SESSION ROOMS - Student Round Table and Awards Banquet/After Party
- RESTROOM - Women
- RESTROOM - Men

82ND ANNUAL MEETING



Welcome to Toronto, eh!

The Host Committee of the 82nd Annual Meeting is looking forward to welcoming everyone to the Society of Vertebrate Paleontology's (SVP) 2022 meeting in Toronto, Ontario, Canada. This meeting represents the first meeting with a significant "in person" component since the Brisbane meeting in 2019, due to the global COVID-19 pandemic. We recognize that we have a unique set of challenges to face this year. On the one hand, we know that the vertebrate paleontology community is hungry for a chance to gather in order to share our science, and revive old friendships and collaborations. But we also know that the pandemic is not over, and that attending the "in person" parts of the meeting represents a risk, particularly to older and disabled members. We have been working hard with the Program and Executive Committees to try and balance members' various expectations and priorities. The result will be our first attempt at a "hybrid" meeting, which will make some elements accessible to participants around the world, while centering an "in person" talk program. We will also be enforcing a strong mask mandate as one part of a strategy to try and reduce the risk to the attendees who make the choice to come to Toronto. We acknowledge that there will be members who disagree with the decisions that have been made. Please know that we are trying our best. We hope that the lessons learned this year will inform a strategy to increase the inclusiveness and accessibility of SVP meetings going forward.

Most of the "in person" meeting will be taking place at the Westin Harbour Castle hotel, on the shores of beautiful Lake Ontario, and a 10-minute walk away from historic Union Station, which is the gateway to all that Toronto has to offer. Participants in the workshops and Field Trip to Research Casting International will have the chance to get out of the city and see some of the scenic landscape of southern Ontario, as well as enjoying a unique opportunity to learn from some of the world's leaders in preparing and mounting museum displays. We are also delighted to welcome Riley Black as our Tuesday night speaker. Her articles and books, including the recently published *The Last Days of the Dinosaurs*, have opened the eyes of a diverse public to the fossils we love, as well as fueling the imagination of us paleontologists.

The venue for the Welcome Reception will be the Royal Ontario Museum (ROM), the largest museum in Canada, and one of the largest in the world. With a mandate that spans art, world culture, and natural history, the ROM is an extraordinary doorway to all aspects of human endeavour, and to the diversity of the natural world, both past and present. Of particular interest to SVP members will be the James and Louise Temerty Galleries of the Age of Dinosaurs, which feature Gordo, the enormous *Barosaurus*, the largest original fossil dinosaur skeleton in Canada, as well as the extraordinary skeleton of the famous tube-crested dinosaur *Parasaurolophus*. We chose to honour the latter in our logo this year (drawn by the talented Danielle Dufault) to mark the 100th anniversary of its original scientific description (Parks, 1922). We are also very excited to share the new Willner Madge Gallery, Dawn of Life, which will take you on a journey spanning almost four billion years. With almost 1,000 fossils in a nearly 10,000 square-foot gallery, and highlighting the ROM's renowned collection of Burgess Shale fossils, this extraordinary permanent exhibition will take you on an interactive journey from our most meagre beginnings to the dawn of the Age of Dinosaurs. The ROM sits on the downtown campus of the University of Toronto, which has a robust history of vertebrate paleontology research and also welcomes SVP to the city.

In addition to vertebrate paleontology, Toronto is a vibrant city known for its diversity as well as for being a cultural hub of Canada. It is with great pleasure that we host the Society here, and we welcome you all to Toronto.

We acknowledge that Toronto sits on ancestral Indigenous lands, some of which is governed by Treaty 13 and the Williams Treaties, and some of which is unceded and still contested. We are grateful for the opportunity to work on this land, and commit to continue to educate ourselves on the history of colonization in Canada.

MARY T. SILCOX AND DAVID C. EVANS
CO-CHAIRS
2022 SVP HOST COMMITTEE

Presentation Policies

SVP Abstracts are reviewed by the Program Committee and members of the Education & Outreach, Preparators', Colbert, and Romer Prize Committees, as appropriate, in a double-blind process. 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 2022 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, 2022*, <insert page number here>.

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. Please note that there is a masking mandate this year. Mask transgressions may be reported to any SVP representative or member wearing a Safe SVP badge

Presentation Policies

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.

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

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
7918 Jones Branch Drive, Suite 300
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.

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 Canada).

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 Margaret Lewis (Margaret.Lewis@stockton.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”.

Presentation Policies

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 #2022SVP. We look forward to seeing your thoughts and discussion online!

TUESDAY, NOVEMBER 1

TIME	TITLE	LOCATION
2:00pm-7:00pm	Registration Open	Frontenac Coat Room
7:00pm-9:00pm	Special Lecture by Riley Black , freelance science writer and the author of <i>The Last Days of the Dinosaurs</i> , <i>Skeleton Keys</i> , and many other natural history books	Metro Centre

WEDNESDAY, NOVEMBER 2

TIME	TITLE	LOCATION
7:00am-7:30pm	Registration Open	Frontenac Coat Room
8:00am-12:15pm	Technical Session 1: Dinosaurs	Metro Centre
	Technical Session 2: Paleoecology	Metro East
	Technical Session 3: Marine Reptiles	Metro West
9:30am-6:30pm	Exhibit and Poster Viewing Hours Colbert Prize Competition Posters (B1-B26) Education and Outreach Poster Session (B27-B39) Preparators' Poster Session (B42-B47) Poster Session 1 (B50-B102)	Frontenac
12:30pm - 1:30pm	National Science Foundation Research and Training Opportunities for Vertebrate Paleontologists Matthew Herron, Program Director, National Science Foundation Division of Biological Infrastructure	Metro Centre
1:45pm-4:15pm	Technical Session 4: Paleobiogeography	Metro Centre
	Symposium: International Community Connections <i>*Symposium posters will also be on display (B27-B28)</i>	Metro East
	Symposium: A Late Miocene Shangri-la: The Remarkable Vertebrates and Paleoenvironment of the Site of Shuitangba, Yunnan Province, China	Metro West
4:30pm-6:30pm	Exhibits/Poster Mixer - Authors will be Present at the Following Posters: Colbert Prize Competition Posters (B1-B26) Poster Session 1 (B50-B102)	Frontenac
7:30pm-10:30pm	Welcome Reception	**Royal Ontario Museum

***The distance from the hotel to the ROM is walkable and accessible via public transportation. SVP will provide transportation as well.

THURSDAY, NOVEMBER 3

TIME	TITLE	LOCATION
7:30am-7:00pm	Registration Open	Frontenac Coat Room
8:00am-12:15pm	Romer Prize Session	Metro Centre
	Technical Session 5: Amphibians & Early Reptiles	Metro East
	Preparators' Session (8:00am-10:00am) New Methods Session (10:15am-12:15pm)	Metro West
9:30am-6:30pm	Exhibit and Poster Viewing Hours Colbert Prize Competition Posters (B1-B26) Education and Outreach Poster Session (B27-B39) Preparators' Poster Session (B42-B47) Poster Session 2 (B103-B156)	Frontenac
1:45pm-4:15pm	Technical Session 6: Dinosaur Macroevolution/Macroecology	Metro Centre
	Technical Session 7: Paleogene Mammals & Primates & Carnivora	Metro East
	Technical Session 8: Evolutionary Developmental Biology	Metro West
4:30pm-6:30pm	Exhibits/Poster Mixer - Authors will be Present at the Following Posters: Preparators' Poster Session (B42-B47) Poster Session 2 (B103-B156)	Frontenac
7:30pm-11:30pm	Student, Postdoc and Diversity Committee Roundtable Forum	Metro West

FRIDAY, NOVEMBER 4

TIME	TITLE	LOCATION
7:30am-7:00pm	Registration Open	Frontenac Coat Room
8:00am-12:15pm	Technical Session 9: Mammals	Metro Centre
	Technical Session 10: Soft Tissues & Taphonomy	Metro East
	Technical Session 11: Synapsida	Metro West
9:30am-6:30pm	Exhibit and Poster Viewing Hours Colbert Prize Competition Posters (B1-B26) Education and Outreach Poster Session (B27-B39) Preparators' Poster Session (B42-B47) Poster Session 3 (B103-B156)	Frontenac
1:45pm-4:15pm	Technical Session 12: Rodents & Quaternary Mammals	Metro Centre
	Technical Session 13: Early Archosaurs & Pterosaurs	Metro East
	Technical Session 14: Squamates & Turtles	Metro West
4:30pm-6:30pm	Exhibits/Poster Mixer - Authors will be Present at the Following Posters: Poster Session 3 (B157-B210)	Frontenac
6:30pm-11:30pm	Annual Benefit Auction and Social	Harbour

SATURDAY, NOVEMBER 5

TIME	TITLE	LOCATION
7:30am-4:00pm	Registration Open	Frontenac Coat Room
8:00am-12:15pm	Technical Session 15: Theropods	Metro Centre
	Technical Session 16: Hoofed Mammals	Metro East
	Technical Session 17: Fish	Metro West
9:30am-6:30pm	Exhibit and Poster Viewing Hours Colbert Prize Competition Posters (B1-B26) Education and Outreach Poster Session (B27-B39) Posters associated with Preparators' Session (B42-B47) Poster Session 4 (B211-B265)	Frontenac
1:45pm-4:15pm	Technical Session 18: Birds	Metro Centre
	Technical Session 19: Marine Mammals	Metro East
	Technical Session 20: Crocodylomorpha	Metro West
4:30pm-6:30pm	Exhibits/Poster Mixer - Authors will be Present at the Following Posters: Education and Outreach Poster Session (B27-B39) Poster Session 4 (B211-B265)	Frontenac
7:30pm-10:00pm	Awards Banquet <i>*Ticket required for admittance</i>	Metro Centre & West
10:30-11:30pm	Trivia Quiz Event	Harbour

Field Trip and Workshops

2022 SVP FIELD TRIP*

DAY/TIME	TITLE	LOCATION
MONDAY October 31, 6:45am – 6:45pm	Visit to Research Casting International	Research Casting International

2022 SVP WORKSHOPS*

DAY/TIME	TITLE	LOCATION
TUESDAY November 1, 6:45am–6:45pm	Visit to Research Casting International	Research Casting International
TUESDAY November 1, 12:30pm-5:00pm	Digital Morphology and Shape Analysis with SlicerMorph Workshop	The Westin Harbour Castle

**For field trip and workshop pickup and dropoff location and time, please check with your workshop or field trip leader, check the mobile app, or go to vertpaleo.org/workshops-2/*

Talks Schedule

WEDNESDAY, NOVEMBER 2

	METRO CENTRE	METRO EAST	METRO WEST
TIME	DINOSAURS	PALEOECOLOGY	MARINE REPTILES
8:00 AM	RAUHUT	TOLCHARD	JANNEL
8:15 AM	ARBOUR	HABIB	VERRIÈRE
8:30 AM	AVRAHAMI	PARDI	GORDON
8:45 AM	DUDGEON	CROWLEY	MIEDEMA
9:00 AM	BARRETT	DESANTIS	SÉON
9:15 AM	MAIDMENT	SCHAP	HIGGINS
9:30 AM	WOODRUFF	WHITTINGHAM	LABOURY
9:45 AM	DE ROOIJ	LAUER	STREET
10:00 AM	COFFEE		
10:15 AM	CHAPELLE	HARDY	DUFFY
10:30 AM	MOCHO	BADGLEY	MORGAN
10:45 AM	JACKSON	MARTIN	SALEM
11:00 AM	GALLAGHER	CORTÉS	HOLWERDA
11:15 AM	MOORE	MACDOUGALL	SHARPE
11:30 AM	GORSCAK	OTOO	FORMOSO
11:45 AM	FRAUENFELDER	KLIGMAN	ROSENFELD
12:00 PM	WHITLOCK	NESBITT	ZIETLOW
12:15 PM	BREAK		
1:30 PM			
	METRO CENTRE	METRO EAST	METRO WEST
TIME	PALEOBIOGEOGRAPHY	INTERNATIONAL COMMUNITY CONNECTIONS	A LATE MIOCENE SHANGRI-LA
1:45 PM	ORGAN	LEPORE	LI
2:00 PM	VALLEJO-PAREJA	HOCK	SU
2:15 PM	CLAESSENS	HOVATTER	SU
2:30 PM	POUST	GOLD	STIDHAM
2:45 PM	TATE-JONES	BURGER	FLYNN
3:00 PM	BEARD	GOLD	KELLEY
3:15 PM	FRASER	MYCHAJLIW	JABLONSKI
3:30 PM	MCMINN	MCRAE	WANG
3:45 PM	CADENA	HOLLIDAY	SANDERS
4:00 PM	TORRES	WILSON	JABLONSKI
4:30 PM	Poster Session 1		
6:30 PM			

Talks Schedule

THURSDAY, NOVEMBER 3

	METRO CENTRE	METRO EAST	METRO WEST
TIME	ROMER PRIZE SESSION*	AMPHIBIANS & EARLY REPTILES	PREPARATORS' SESSION & NEW METHODS
8:00 AM	REYNOLDS	STEWART	RAMOS
8:15 AM	ELSHAFIE	WHITNEY	FIKE
8:30 AM	ELY	PARDO	BROWNE
8:45 AM	OLROYD	IGIELMAN	PINSDORF
9:00 AM	LESSNER	HIRASAWA	SHINYA
9:15 AM	GRIFFIN	KORNEISEL	HAUGRUD
9:30 AM	SCHWAB	MARJANOVIĆ	BEHLKE
9:45 AM	MANAFZADEH	GEE	DAVISON
10:00 AM	COFFEE		
10:15 AM	PARKER	SO	BROUGHAM
10:30 AM	BARRETT	LEMIERRE	HART
10:45 AM	SCHROEDER	JENKINS	SCHRØDER
11:00 AM	ROBERTS	SUES	POLLY
11:15 AM	ENGELMAN	JENKINS	WHITEBONE
11:30 AM	NAPOLI	SANCHEZ	WILENZIK
11:45 AM	BUFFA	LEGENDRE	MARCHETTI
12:00 PM	HARIDY	SUMIDA	DOLLMAN
12:15 PM	BREAK		
1:30 PM			
	METRO CENTRE	METRO EAST	METRO WEST
TIME	DINOSAUR MACROEVOLUTION/ MACROECOLOGY	PALEOGENE MAMMALS & PRIMATES & CARNIVORA	EVOLUTIONARY DEVELOPMENTAL BIOLOGY
1:45 PM	GARDNER	GILL	ATKINS
2:00 PM	CULLEN	MAGALLANES	MORRIS
2:15 PM	CHIARENZA	BORTHS	BHULLAR
2:30 PM	VORIS	BERTRAND	MAREK
2:45 PM	GRIFFIN	WITT	BUCHHOLTZ
3:00 PM	FUNSTON	CHATAR	ASHER
3:15 PM	D'EMIC	JONES	WHITE
3:30 PM	HOLTZ	CROWELL	HERRIDGE
3:45 PM	SCHROEDER	KAY	GOSWAMI
4:00 PM	QIN	KINGSTON	ASHBAUGH
4:30 PM	Poster Session 2		
6:30 PM			

*Romer Prize Session will be filmed.

Talks Schedule

FRIDAY, NOVEMBER 4

	METRO CENTRE	METRO EAST	METRO WEST
TIME	MAMMALS	SOFT TISSUES & TAPHONOMY	SYNAPSIDA
8:00 AM	GOSWAMI	FIGUEROA	MANN
8:15 AM	SAMUELS	GAETANO	BRINK
8:30 AM	CALAMARI	SMITH	CANOVILLE
8:45 AM	MCAFEE	WOOD	GROSSNICKLE
9:00 AM	BURROUGHS	WIEMANN	SINGH
9:15 AM	O'KEEFE	CERIO	JONES
9:30 AM	KAUR	ONEALL	JIRAH
9:45 AM	HUYNH	QVARNSTROM	LUNG MUS
10:00 AM	COFFEE		
10:15 AM	FULGHUM	BOYD	VIGLIETTI
10:30 AM	PANSANI	TSAI	HUTTENLOCKER
10:45 AM	MELTESEN	WHITLOCK	SIDOR
11:00 AM	ORCUTT	PARSONS	KAMMERER
11:15 AM	EVERETT	LYMAN	ABBOTT
11:30 AM	BARI	WOOLLEY	ANGIELCZYK
11:45 AM	FOX	HANNEBAUM	GEORGE
12:00 PM	ARMSTRONG	TUCKER	KULIK
12:15 PM	BREAK		
1:30 PM			
	METRO CENTRE	METRO EAST	METRO WEST
TIME	RODENTS & QUATERNARY MAMMALS	EARLY ARCHOSAURS & PTEROSAURS	SQUAMATES & TURTLES
1:45 PM	KERR	CZEPINSKI	ARMPFIELD
2:00 PM	JUKAR	BYRNE	MARTINEZ
2:15 PM	PEECOOK	DEMUTH	PETERMANN
2:30 PM	VINOLA	SPIEKMAN	POWERS
2:45 PM	HAVELES	WHATLEY	MEYER
3:00 PM	LÓPEZ-TORRES	FOFFA	HEAD
3:15 PM	KALTHOFF	WELCH	SAMUELS
3:30 PM	MACIAS	JAGIELSKA	SMITH
3:45 PM	LINDSEY	FITCH	SHIPPS
4:00 PM	MILLER	THOMAS	TADA
4:30 PM	Poster Session 3		
6:30 PM			

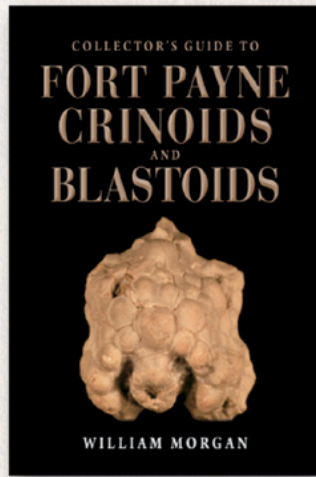
Talks Schedule

SATURDAY, NOVEMBER 5

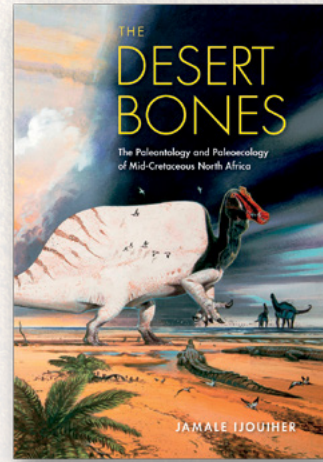
	METRO CENTRE	METRO EAST	METRO WEST
TIME	THEROPODS	HOOFED MAMMALS	FISH
8:00 AM	RUEBENSTAHL	ROBSON	MIYASHITA
8:15 AM	MAKOVICKY	BALCARCEL	RIVERO-VEGA
8:30 AM	CARR	HUMMEL	CARON
8:45 AM	HEDGE	FINCK	WILSON
9:00 AM	HART-FARRAR	COHEN	JOHANSON
9:15 AM	WILKINSON	PUSCHEL	KNAPP
9:30 AM	NOTTRODT	ORLOWSKI	WILSON
9:45 AM	SIMON	SCOTT	DRUMHELLER
10:00 AM	COFFEE		
10:15 AM	SMITH	CANTALAPIEDRA	AMADORI
10:30 AM	SOMBATHY	WEAVER	STACK
10:45 AM	MALLON	LANDRY	ROSE
11:00 AM	SLOWIAK-MORKOVINA	TISSIER	VILLALOBOS-SEGURA
11:15 AM	WARNOCK-JUTEAU	ROTHSCHILD	JAMBURA
11:30 AM	PALOMBI	PATERSON	TÜRTSCHER
11:45 AM	FABBRI	KHAN	LÓPEZ-ARBARELLO
12:00 PM	WU	SANISIDRO	DURING
12:15 PM	BREAK		
1:30 PM			
	METRO CENTRE	METRO EAST	METRO WEST
TIME	BIRDS	MARINE MAMMALS	CROCODYLORPHA
1:45 PM	TORRES	GOHAR	JOHNSON
2:00 PM	LOWI-MERRI	BOESSENECKER	ALLEN
2:15 PM	MILLER	NELSON	MOHLER
2:30 PM	FELICE	BENITES PALOMINO	VELEZ-ROSADO
2:45 PM	KUO	CHURCHILL	RIEGLER
3:00 PM	HOUDE	GLASS	ERB
3:15 PM	GIOVANARDI	GUO	NICHOLL
3:30 PM	NAVALON	CLEMENTZ	SCAVEZZONI
3:45 PM	CHEN	LAKER	GEARTY
4:00 PM	STEELL	UHEN	FORTNER
4:30 PM	Poster Session 4		
6:30 PM			



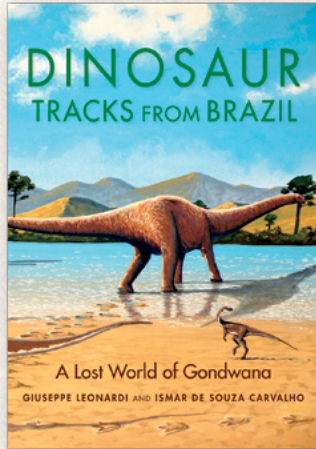
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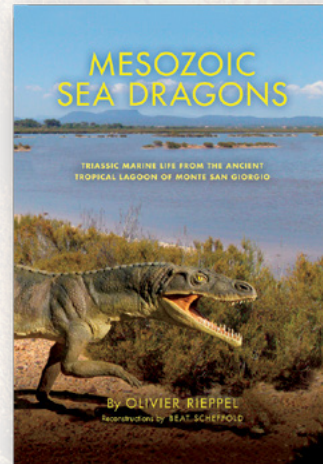
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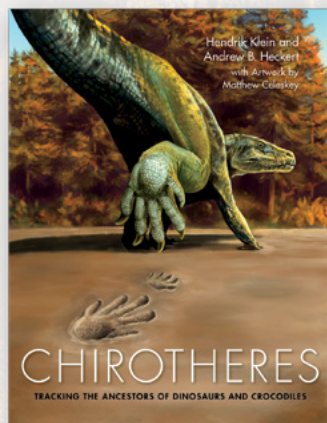


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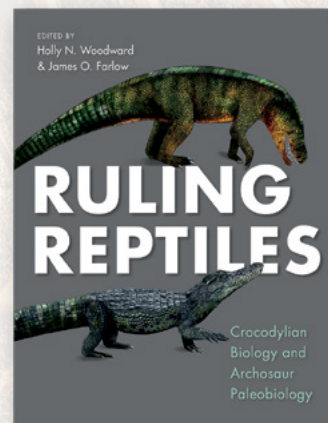


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List of Authors and Abstract Titles in Chronological Session Order

WEDNESDAY MORNING, NOVEMBER 2, 2022

TECHNICAL SESSION 1: DINOSAURS

MEETING ROOM METRO CENTRE

MODERATORS: Paul Barrett and Susannah Maidment

- 8:00 **O. Walter Mischa Rauhut, D. Pol, J. Carballido, A. Reutter Wagner** NEW DATA ON LATE JURASSIC GONDWANAN DINOSAUR FAUNAS FROM THE OXFORDIAN-KIMMERIDGIAN CAÑADÓN CALCÁREO FORMATION OF CHUBUT, ARGENTINA
- 8:15 **V. Arbour, T. Cullen, D.W. Larson, J. Richmond** A NEW MAASTRICHTIAN-AGED DINOSAUR LOCALITY IN THE SUSTUT BASIN OF SPATSIZI PLATEAU WILDERNESS PROVINCIAL PARK, NORTHERN BRITISH COLUMBIA, CANADA
- 8:30 **H.M. Avrahami, P. Makovicky, L.E. Zanno** A NEW ORODROMINE FROM THE MUSSENTUCHIT MEMBER OF THE CEDAR MOUNTAIN FORMATION, UTAH
- 8:45 **T.W. Dudgeon, D.C. Evans** THE INFLUENCE OF SUPRACRANIAL CRESTS ON FEEDING MECHANICS IN HADROSAURIDS (ORNITHISCHIA: ORNITHOPODA)
- 9:00 **P.M. Barrett, L.B. Porro, S. Lautenschlager, M.E. Jones, D. Button** DIVERGENT STRATEGIES FOR HIGH-FIBER HERBIVORY AMONG EARLY-DIVERGING ORNITHISCHIAN DINOSAURS
- 9:15 **S. Maidment, S.B. Pond, T.J. Raven, J.A. Lockwood, J.A. Bonsor** NEW ORNITHISCHIAN DINOSAURS FROM THE WEALDEN SUPERGROUP OF SOUTHERN ENGLAND
- 9:30 **C. Woodruff** OSTEOLOGY AND KINEMATICS OF THE PACHYCEPHALOSAURID VERTEBRAL COLUMN PROVIDES FURTHER EVIDENCE REFUTING THE AGONISTIC HEAD-BUTTING HYPOTHESIS
- 9:45 **J. de Rooij, S.A. Lucassen, P.M. Sander, A.S. Schulp** OSTEOHISTOLOGY OF *TRICERATOPS* FORE- AND HINDLIMB: IMPLICATIONS FOR GROWTH, DEVELOPMENT AND TAXONOMY
- 10:15 **K.E. Chapelle, V. Fernandez, D. Pol** INVESTIGATING EARLY BRANCHING SAUROPODOMORPH EMBRYONIC ANATOMY AND DEVELOPMENT
- 10:30 **P. Mocho, F. Escaso, F. Marcos-Fernández, A. Páramo, D. Vidal, F. Ortega** LO HUECO FOSSIL-SITE (CAMPANIAN-MAASTRICHTIAN, SPAIN), AN IMPORTANT BRICK TO UNDERSTAND THE COMPLEX SYSTEMATICS OF EUROPEAN TITANOSAURS
- 10:45 **L.S. Jackson, N.D. Smith, P. Makovicky** CRANIAL DESCRIPTION OF A NEW BASAL SAUROPODOMORPH FROM THE EARLY JURASSIC OF ANTARCTICA
- 11:00 **T. Gallagher, S. Kirkton, J. Schein** SKIN DEEP WITH *DIPLODOCUS*: IMPLICATIONS FOR THERMOREGULATION IN THE POROUS SCALES OF A YOUNG *DIPLODOCUS*
- 11:15 **A. Moore, P.M. Barrett, P. Upchurch, C. Liao, Y. Ye, X. Xu** RE-EVALUATION OF *MAMENCHISAURUS SINOCANADORUM* (SAUROPODA: MAMENCHISAURIDAE) AND NOVEL INTERPRETATION OF ENIGMATIC JUVENILE SAUROPODS AS MAMENCHISAURIDS
- 11:30 **E. Gorscak, P.D. Mannion** AN ASSESSMENT OF THE SAUROPOD DINOSAUR FOSSILS COLLECTED FROM THE CRETACEOUS DINOSAUR BEDS OF MALAWI DURING THE 1930 F.W.H. MIGEOD EXPEDITION
- 11:45 **T. Frauenfelder, S. Brougham, P. Bell, N. Campione** TOOTH BREADTH EVOLUTION WITHIN SAUROPODOMORPHA AND IMPLICATIONS FOR TAXONOMIC IDENTIFICATION OF ISOLATED TEETH
- 12:00 **J.A. Whitlock, J.P. Garderes, M. Militello, N. Toledo, P.A. Gallina** RETRO-ACUPUNCTURE: CRANIOCERVICAL MUSCULATURE OF THE DICRAEOSAURID SAUROPOD DINOSAUR *BAJADASAURUS PRONUSPINAX*

WEDNESDAY MORNING, NOVEMBER 2, 2022
TECHNICAL SESSION 2: PALEOECOLOGY
MEETING ROOM METRO EAST
MODERATORS: Larisa DeSantis and Mark MacDougal

- 8:00** **F. Tolchard, R. Benson, J. Choiniere** MACROEVOLUTIONARY DYNAMICS OF DIET IN AMNIOTES
- 8:15** **M.B. Habib** PLAYING (AERODYNAMIC) SLOTS: EVOLUTION OF THE AVIAN WINGTIP WITH IMPLICATIONS FOR ECOLOGICAL INFERENCES FROM WING SHAPE IN AVIAN AND NON-AVIAN THEROPODS
- 8:30** **M.I. Pardi, L.R. DeSantis** ECOLOGICAL NICHE MODELING AND STABLE ISOTOPE ANALYSIS PROVIDE INSIGHT INTO DIETARY VARIATION OF MAMMOTH (*MAMMUTHUS*) ACROSS ENVIRONMENTS IN NORTH AMERICA
- 8:45** **B. Crowley, L. Godfrey, K. Samonds** WHAT CAN HIPPO ISOTOPES TELL US ABOUT PAST DISTRIBUTION OF C₄ GRASSY BIOMES ON MADAGASCAR?
- 9:00** **L.R. DeSantis, J.A. Meachen, J.H. Miller, R. Dunn, E.L. Lindsey, M.I. Pardi, J.R. Southon, W.J. Binder, J. Cohen, F.R. O'Keefe, E. Mueller** A COYOTE IN THE "COAL MINE," OR TAR PIT: ECOLOGICAL CONSEQUENCES OF MEGAFAUNAL EXTIRPATION AND ANTHROPOGENIC IMPACTS
- 9:15** **J.A. Schap, R.A. Short, J.L. McGuire** BUILDING ECOMETRIC MODELS USING SMALL MAMMAL HYPSONDONTY TO OBSERVE NOVEL TRAIT-ENVIRONMENTAL RELATIONSHIPS THROUGH TIME IN AFRICA
- 9:30** **M. Whittingham, V. Korasidis, D. Fraser** CHANGING CLIMATE PREFERENCES AND FUNCTIONAL STASIS IN MAMMALIAN COMMUNITIES ACROSS THE PALEOCENE-EOCENE THERMAL MAXIMUM OF THE BIGHORN BASIN, WYOMING
- 9:45** **D.A. Lauer, A.M. Lawing, R.A. Short, F.K. Manthi, J. Muller, J.J. Head, J.L. McGuire** DISRUPTION OF TRAIT-ENVIRONMENT RELATIONSHIPS IN AFRICAN MEGAFAUNA COINCIDENT WITH HOMININ EMERGENCE
- 10:15** **F. Hardy, C. Badgley, X. Wang** DIETARY PALEOECOLOGY OF UNGULATES IN RELATION TO ENVIRONMENTAL CHANGE IN THE MIOCENE DOVE SPRING FORMATION, CALIFORNIA
- 10:30** **C. Badgley, J.C. Barry, L.J. Flynn, M.E. Morgan, D. Pilbeam** DIFFERENT MACROECOLOGICAL HISTORIES FOR SMALL AND LARGE MAMMALS IN THE MIOCENE SIWALIK RECORD OF PAKISTAN
- 10:45** **A. Martin, M. Lowery, M. Hall, D. Seegets-Villier, P. Swinkels, L. Kool, T. Rich, P. Vickers-Rich** POLAR DINOSAUR TRACKS GREAT AND SMALL IN THE EARLY CRETACEOUS WONTHAGGI FORMATION OF VICTORIA, AUSTRALIA
- 11:00** **D. Cortés, H.C. Larsson, J. Parra** THE EARLY CRETACEOUS PAJA FORMATION BIOTA IN COLOMBIA REVEALS A COMPLEX ECOLOGICAL NETWORK WITH HIGH PREDATOR DIVERSITY SUPPORTED BY MULTIPLE MID-TROPHIC LEVELS
- 11:15** **M.J. MacDougal, L. Marchetti, S. Flietel, J. Fröbisch** NEW INSIGHTS INTO THE PALEOECOLOGY OF THE EARLY PERMIAN BROMACKER LOCALITY, THURINGIA, GERMANY, BASED ON ANALYSES OF RELATIVE ABUNDANCE
- 11:30** **B. Otoo, M.I. Coates, P. Roopnarine, K.D. Angielczyk** FIRST STEPS UNDER DURESS: ECOLOGICAL EVACUATION, EXPANSION AND EXCLUSION FOLLOWING THE END-DEVONIAN MASS EXTINCTION
- 11:45** **B. Kligman, A. Marsh, W.G. Parker, S.J. Nesbitt, W.A. Reyes, B. Gee, M.E. Smith, H. Sues, M. Stocker** NEW LATE TRIASSIC PALEOCOMMUNITY RECALIBRATES THE RISE OF THE MODERN TETRAPOD EVOLUTIONARY FAUNA, PLACING NEW CONSTRAINTS ON EARLY MESOZOIC EXTINCTIONS
- 12:00** **S.J. Nesbitt, M. Stocker, B. Kligman, K.D. Angielczyk, C. Sidor, D. Hoffman, R. Smith** A RARE MICROVERTEBRATE ASSEMBLAGE FROM THE TRIASSIC MANDA BEDS OF TANZANIA FILLS IN THE RECORD OF VERTEBRATE RECOVERY AFTER THE END-PERMIAN EXTINCTION

WEDNESDAY MORNING, NOVEMBER 2, 2022
TECHNICAL SESSION 3: MARINE REPTILES
MEETING ROOM METRO WEST
MODERATORS: Hallie Street and Amelia Zietlow

- 8:00** A. Jannel, J. Fröbisch, V. Fernandez, A. Verrière A TWIST IN THE TAIL: RECONSTRUCTING UNDULATORY SWIMMING IN THE FIRST SECONDARILY AQUATIC AMNIOTE
- 8:15** A. Verrière ONTOGENY OF THE OLDEST SECONDARILY AQUATIC REPTILE: WHAT MESOSAURS TELL US ABOUT THE EVOLUTION OF DEVELOPMENT IN EARLY AMNIOTES
- 8:30** C.M. Gordon, B.S. Bhullar, J. Gauthier VALIDATING OSTEOLOGICAL CORRELATES OF INTERDIGITAL WEBBING AND FLIPPER FORM IN EXTINCT AQUATIC AMNIOTES.
- 8:45** F. Miedema, G. Bindellini, C. Dal Sasso, T.M. Scheyer, E. Maxwell ONTOGENETIC VARIATION IN THE CRANIUM OF *MIXOSAURUS CORNALIANUS* SHOWS DEVELOPMENTAL TRANSITION OVER ICHTHYOSAUR EVOLUTIONARY HISTORY
- 9:00** N. Séon, P. Vincent, L.L. Delsett, A.J. Roberts, G. Suan, C. Lécuyer, F. Fourel, J.H. Hurum, S. Charbonnier, R. Amiot INTRA-SKELETAL VARIABILITY IN PHOSPHATE OXYGEN ISOTOPE COMPOSITION OF MARINE VERTEBRATES AS A TOOL TO TRACK REGIONAL HETEROTHERMIES IN MESOZOIC MARINE REPTILES
- 9:15** R. Higgins, S.L. Brusatte, M. Young, J. Schwab, L.M. Witmer, O. Katsamenis, S. Walsh, Y. Herrera, T. Cowgill, C. Bowman THE INTERNAL BRAINCASE ANATOMY OF *THALATTOSUCHUS SUPERCILIOSUS* -- WITH IMPLICATIONS FOR THE ENDOCRANIAL EVOLUTION OF METRIORHYNCHID CROCODYLOMORPHS
- 9:30** A. Laboury, T.M. Scheyer, T. Stubbs, K. Nicole, V. Fischer QUANTIFYING THE EARLY ECOMORPHOLOGICAL DIVERSIFICATION OF EOSAUROPTERYGIA
- 9:45** H.P. Street, W.S. Persons, A. Kelley A NEW LONG-NECKED POLYCOTYLID (PLESIOSAURIA: POLYCOTYLIDAE) FROM THE PIERRE SHALE OF WYOMING, U.S.A.
- 10:15** F. Duffy, K. Chin COPROLITE EVIDENCE FOR MARINE VERTEBRATE MIGRATION IN THE WARM CRETACEOUS ARCTIC
- 10:30** D.J. Morgan, S. Tada, L.M. Witmer CRANIAL VASCULAR PATTERNING IN MOSASAUROIDEA AND SAUROPTERYGIA
- 10:45** B.S. Salem, P.M. O'Connor, M.C. Lamanna, S. El-Sayed, E.R. Seiffert, J.J. Sertich, H.M. Sallam NEW MARINE REPTILE (PLESIOSAUR AND MOSASAUR) FOSSILS FROM THE UPPER CRETACEOUS DUWI FORMATION OF THE DAKHLA OASIS AREA, WESTERN DESERT OF EGYPT
- 11:00** F.M. Holwerda MOSASAUR MEMOIRS: ECOLOGICAL SIGNALS DERIVED FROM DENTAL MICROWEAR AND GEOCHEMICAL ANALYSIS IN ALBERTAN BEARPAW FORMATION MOSASAURS
- 11:15** H.S. Sharpe, M.J. Powers, A.R. Zietlow, D.C. Evans VENOM-ASSISTED FEEDING IN MOSASAURS IMPLIED BY COMPARATIVE MANDIBULAR BIOMECHANICS
- 11:30** K.K. Formoso, M.B. Habib, R.L. Cieri RELATIVE SWIMMING BURST CAPABILITIES IN MOSASAURS: INSIGHTS INTO MOSASAUR ECOLOGY AND EVOLUTION
- 11:45** T. Rosenfeld, J. Wostbrock, J. Gauthier TRIPLE OXYGEN ISOTOPES FROM SKELETAL CARBONATES AS A PROXY FOR HABITAT IN EXTANT AND EXTINCT *TESTUDINES*
- 12:00** A.R. Zietlow, C. Boyd, N.E. Van Vranken A NEW MOSASAURINE FROM THE PIERRE FORMATION (PEMBINA MEMBER: CAMPANIAN) OF NORTH DAKOTA

WEDNESDAY AFTERNOON, NOVEMBER 2, 2022
TECHNICAL SESSION 4: PALEOBIOGEOGRAPHY
MEETING ROOM METRO CENTRE
MODERATORS: Ashley Poust and Danielle Fraser

- 1:45** C. Organ, L. Keller, J.D. Gardner BERGMANN'S RULE WAS ABSENT IN MESOZOIC DINOSAURS AND MAMMALS

- 2:00 M.C. Vallejo-Pareja, A.F. Rincón, J.I. Bloch, D.C. Blackburn** HOPPING THROUGH THE ISTHMUS: FOSSIL FROGS AND TOADS FROM THE EARLY MIOCENE CUCARACHA FORMATION OF PANAMA
- 2:15 L. Claessens, A. Janoo, A. van Heteren, J. Hume, J. de Groeve, H. Meijer, K. Rijdsdijk** NEW INSIGHTS INTO ISLAND EVOLUTIONARY DYNAMICS FROM THE DODO (*RAPHUS CUCULLATUS*) AND THE SOLITAIRE (*PEZOPHAPS SOLITARIA*)
- 2:30 A.W. Poust, T.A. Deméré** PLEISTOCENE MARINE VERTEBRATES FROM SANTA CRUZ ISLAND AND THE TEMPO AND MODE OF ASSEMBLY OF THE QUATERNARY EASTERN NORTH PACIFIC MARINE FAUNA
- 2:45 K. Tate-Jones, E.B. Davis** FOSSILS FOR THE FUTURE: USING WALRUS PALEODISTRIBUTION TO PREDICT THEIR RESPONSE TO ANTHROPOGENIC CLIMATE CHANGE
- 3:00 K. Beard, D. Peppe, M.F. Jones, K. Miller, P. Rhinehart, K. Rust** NEW CONSTRAINTS ON THE TIFFANIAN-CLARKFORKIAN BOUNDARY (LATE PALEOCENE) IN SOUTHERN WYOMING
- 3:15 D. Fraser, M. Gilbert, N. Rybczynski, M. Dawson** POST-EOCENE RHINOCEROTID DISPERSAL VIA THE NORTH ATLANTIC
- 3:30 J.K. McMinn, E. Saupe, A. Goswami** THERE AND BACK AGAIN? PREDICTING MARSUPIAL DISPERSAL ACROSS PALAEOGENE GONDWANA USING THE NICHES OF EXTANT TAXA
- 3:45 E. Cadena** NEW NEOTROPICAL FOSSIL TURTLES FROM COLOMBIA, VENEZUELA, AND PANAMA; PALEOBIOGEOGRAPHICAL AND EVOLUTIONARY HISTORY IMPLICATIONS
- 4:00 F.J. Torres, J. Roman Carrion, G.S. Bever** CONTINENTAL GIGANTISM IN A PLEISTOCENE TORTOISE FROM ECUADOR RAISES QUESTIONS REGARDING THE DEEP HISTORY OF THE GALAPAGOS LINEAGE

WEDNESDAY AFTERNOON, NOVEMBER 2, 2022
SYMPOSIUM: INTERNATIONAL COMMUNITY CONNECTIONS
MEETING ROOM METRO EAST

MODERATORS: Taormina Lepore and David Levering

- 1:45 T.J. Lepore, J. Lu, L.J. Hlusko** ASSESSING THE IMPACT OF INCLUSIVE DESIGN EDUCATION IN PALEOBIOLOGY COLLEGE COURSES
- 2:00 D.G. Hock, D. Levering, B. Gomez** USING A VIRTUAL CONSTRUCT OF THE PERMIAN KAROO SUPERGROUP TO TEACH HIGH SCHOOLERS FIELD SURVEY SKILLS, BIOSTRATIGRAPHY, AND EVIDENCE-BASED PROBLEM SOLVING
- 2:15 B.T. Hovatter, G.P. Wilson Mantilla, K. Canning, D. Leatherman** THE DISCOVERIES IN GEOSCIENCES (DIG) FIELD SCHOOL: CONNECTING TEACHERS WITH RESEARCHERS AND MUSEUMS TO INSPIRE STUDENTS WITH REAL SCIENCE IN THE CLASSROOM
- 2:30 M.E. Gold, E. Dewar, H. Dwyer** TEACHING WRITING SKILLS IN ONLINE AND IN-PERSON PALEONTOLOGY AND EVOLUTION COURSES
- 2:45 B. Burger** DESIGNING INTERACTIVE EXPERIENCES IN ONLINE PALEONTOLOGY EDUCATION: GAMIFICATION, VIDEOS, QUESTS, BROADCASTS, FOSSIL EXPEDITIONS, AND OTHER NOVEL IDEAS FOR MAKING ONLINE CLASSES FUN AND EXCITING
- 3:00 M.E. Gold, A.R. West, J. Liu** MULTI-LANGUAGE TRANSLATION OF *SHE FOUND FOSSILS*: A SELF-PUBLISHED CHILDREN'S BOOK ON WOMEN IN PALEONTOLOGY
- 3:15 A. Mychajliw, R.S. Mohammed** COLLECTING IN THE CARIBBEAN: HOW PAST PALEONTOLOGICAL PRACTICES SHAPE PRESENT DAY RESEARCH AND ENGAGEMENT IN TRINIDAD & TOBAGO
- 3:30 R. McRae, B. Pobiner, M. Salim, E. Tunick, L. Appelbaum, C. Oduol** COLLABORATIVE LEARNING: CO-DEVELOPMENT OF AN INTERACTIVE PALEONTOLOGY-FOCUSED SCHOOL PROGRAM BY THE SMITHSONIAN INSTITUTION AND THE NATIONAL MUSEUMS OF KENYA
- 3:45 C. Holliday, E. Lessner, A. Lawrence, C. Cranor, A. Lagorio, K. Sellers, M. Fields, A. Wilken, S. Sullivan, K. Middleton, C. Ward** ALL ABOARD THE STEAM BUS WITH DINOSAURS AND CAVEMEN

- 4:00** **L.E. Wilson, K. O'dell, R. Sanford** #SCICOMM IN THE CLASSROOM: AN ONGOING STORY OF TRIAL AND ERROR, PROFESSIONAL DEVELOPMENT, AND BUILDING A FOUNDATION
- B27** **B. Pobiner, H. Chirchir** EVOLUTION ACCEPTANCE AND COMFORT WITH EVOLUTION CONTENT AMONG KENYAN HIGH SCHOOL BIOLOGY TEACHERS
- B28** **M. Wosik, L. Little** USING INTANGIBLE FOSSIL ALTERNATIVES WHEN DESIGNING EXHIBITS – A CASE STUDY OF A PALEOHISTOLOGY ART GALLERY

WEDNESDAY AFTERNOON, NOVEMBER 2, 2022
SYMPOSIUM: A LATE MIOCENE SHANGRI-LA: THE REMARKABLE VERTEBRATES
AND PALEOENVIRONMENT OF THE SITE OF SHUITANGBA, YUNNAN PROVINCE, CHINA
MEETING ROOM METRO WEST

MODERATORS: Nina Jablonski, Denise F. Su and Xueping Ji

- 1:45** **P. Li, C. Zhang, J. Kelley, C. Deng, N.G. Jablonski, H. Wu, Z. Guo** GEOCHEMISTRY AND CLIMATE CHANGE DURING THE LATE MIOCENE AND PLIOCENE IN YUNNAN, SOUTHWESTERN CHINA
- 2:00** **D.F. Su, F. Sun, Y. Wang, N.G. Jablonski, S. Hou, X. Ji** AN ISOTOPIC PERSPECTIVE ON HABITATS AND CLIMATIC CONDITIONS IN THE LATE MIOCENE SHUITANGBA
- 2:15** **D.F. Su, J. Kelley, L.J. Flynn, X. Ji, N.G. Jablonski** SHUITANGBA: OVERVIEW, TAPHONOMY, AND PALEOENVIRONMENT
- 2:30** **T.A. Stidham, Z. Li, X. Ji** THE DIVERSE WATERBIRDS OF THE LATE MIOCENE SITE OF SHUITANGBA (YUNNAN PROVINCE, CHINA) AND THEIR HABITATS
- 2:45** **L.J. Flynn, J. Kelley, Q. Li, N.G. Jablonski, D.F. Su, X. Ji** THE SHUITANGBA MICROFAUNA: A LATE MIOCENE WINDOW TO AN INDOMALAYAN WETLAND COMMUNITY
- 3:00** **J. Kelley, L.J. Flynn, D.F. Su** CLOSE AND YET SO FAR: COMPARING THE PRIMATE FAUNAS IN THE LATE MIOCENE OF YUNNAN, CHINA
- 3:15** **N.G. Jablonski, D. Youlatos, J. Kelley, X. Ji** THE EVOLUTIONARY AND BIOGEOGRAPHIC SIGNIFICANCE OF THE COLOBINE MONKEY, *MESOPITHECUS PENTELICUS*, AT SHUITANGBA LOCALITY, CHINA
- 3:30** **X. Wang, D.F. Su, N.G. Jablonski, X. Ji, J. Kelley, L.J. Flynn, T. Deng** MUST WALK AND “CHEW”: THE FALSE THUMB OF THE GIANT PANDA FROM SHUITANGBA SUGGESTS CONFLICTING DEMANDS FOR LOCOMOTION AND FEEDING IN THE EARLIEST PANDAS
- 3:45** **W.J. Sanders, X. Ji, N.G. Jablonski** THE MORPHOLOGY AND ECOLOGY OF THE EARLIEST PHASE OF *STEGODON* (STEGODONTIDAE, PROBOSCIDEA, MAMMALIA) AT THE SITE OF SHUITANGBA, ZHAOTONG, CHINA
- 4:00** **N.G. Jablonski, J. Kelley, L.J. Flynn, D.F. Su, C. Deng, X. Ji** SHUITANGBA PRESENTS A REMARKABLE SNAPSHOT OF LATE MIOCENE VERTEBRATE EVOLUTION IN EAST ASIA

WEDNESDAY – SATURDAY, NOVEMBER 2-5, 2022

COLBERT PRIZE POSTER SESSION

MEETING ROOM FRONTENAC

Authors must be present from 4:30 – 6:30 p.m. on Wednesday, November 2 and Thursday, November 3

- B1** **M. Greif, H. Ferron, M.I. Coates, C. Klug** A MINUTE CHONDRICHTHYAN MECKEL'S CARTILAGE FROM THE HANGENBERG BLACK SHALE IN MOROCCO AND ITS POSITION IN CHONDRICHTHYAN JAW MORPHOSPACE
- B2** **M.E. Jobbins, M. Rücklin, H. Ferron, C. Klug** A NEW SELENOSTEID PLACODERM FROM THE LATE DEVONIAN OF THE EASTERN ANTI-ATLAS (MOROCCO) WITH PRESERVED BODY OUTLINE AND ITS ECOMORPHOLOGY
- B3** **Y. Uno, T. Hirasawa** EVOLUTION OF THE PROPATAGIUM IN THEROPOD DINOSAURS: ANALYSES OF ARTICULATED FOSSIL SKELETONS AND EXTANT AVIAN EMBRYOS

- B4** T.C. Wyenberg-Henzler, D. D'Amore, C. Sullivan PATTERNS OF MACROWEAR ON IN SITU TYRANNOSAURID DENTITIONS FROM THE UPPER CRETACEOUS OF NORTH AMERICA
- B5** V. Beccari, A. Villa, O. Walter Mischa Rauhut WHAT IS *KALLIMODON*? REVIEWING THIS STEM SPHENODONTID WITH IMPLICATIONS FOR A NEW SPECIES
- B6** M. Bushell SPECIES DISTRIBUTION MODELING (SDM) OF SEVERAL EMYDIDS IN LATEST PLEISTOCENE NORTH AMERICA WITH IMPLICATIONS ON THE IDENTIFICATION OF *GLYPTEMYS INSCULPTA* IN THE AMERICAN SOUTHEAST
- B7** E.R. Goldsmith, M. Stocker A QUANTITATIVE ANALYSIS OF ALVEOLAR SPACING IN AN ONTOGENETIC SERIES OF MYSTRIOSUCHINE PARASUCHIDS AND IMPLICATIONS FOR THE EVOLUTION OF DENTAL COMPLEXITY IN PHYTOSAURIA
- B8** E. Cowgill-Warner, A. LuJan DINOSAUR EATER: NEW INFORMATION ON THE ANATOMY AND PALEOECOLOGY OF THE GIGANTIC ALLIGATOROID *DEINOSUCHUS RIOGRANDENSIS* FROM THE UPPER CRETACEOUS AGUJA FORMATION OF WEST TEXAS
- B9** R. Buchmann, T. Rodrigues THE CONTRIBUTION OF SOFT TISSUES TO THE NECK OF PTEROSAURS
- B10** E.E. Brown, P.M. Barrett, R.J. Butler, S. Maidment TOOTH REPLACEMENT CYCLES AND THE ENDOCRANIAL ANATOMY OF A NEW ORNITHOPOD DINOSAUR FROM THE LATE CRETACEOUS OF ANTARCTICA
- B11** M. Son, P. Makovicky, G. Erickson CRANIAL ONTOGENETIC VARIATION IN *PSITTACOSAURUS* WITH A CLADISTIC APPROACH AND ITS CONGRUENCE WITH CHRONOLOGICAL AGE
- B12** V.J. Radermacher, P. Makovicky MACROEVOLUTION OF THE ORNITHISCHIAN DENTAL BATTERY
- B13** K. Kubo, Y. Kobayashi, C. Tsogtobaatar, K. Tsogtobaatar A NEW ALVAREZSAURID FROM THE UPPER CRETACEOUS OF MONGOLIA REVEALS A TAXONOMIC DIVERSIFICATION AND AN ADAPTATION FOR AGILITY OF ALVAREZSAURIDS
- B14** M. Serio, D. Varricchio FIRST FORELIMB RECONSTRUCTION AND RANGE OF MOTION ASSESSMENT OF THE LATE CRETACEOUS DINOSAUR *TROODON FORMOSUS*
- B15** M.R. Forcellati, T.L. Green, A. Watanabe DISTINCT LINEAGE-SPECIFIC DEVELOPMENTAL TRAJECTORIES UNDERLIE BRAIN SHAPE DIVERSIFICATION IN RATITES (AVES: PALAEOGNATHAE)
- B16** E.S. Hunt, R.N. Felice, J. Tobias, D.J. Field, S. Lautenschlager, A. Goswami ELUCIDATING THE ECOLOGICAL AND LIFE HISTORY DRIVERS OF AVIAN SKULL EVOLUTION USING HIGH DENSITY 3D GEOMETRIC MORPHOMETRICS
- B17** E. Bogner, Z. Tseng IS MORE DATA WORTH IT?: CREATING LIFELIKE FINITE ELEMENT MODELS FOR PALEOBIOLOGICAL STUDIES
- B18** K. Rust, K. Tietjen, X. Ni, K. Beard A NEW ADAPIFORM (EKG MOWECHASHALIDAE, PRIMATES) FROM THE NADUO FORMATION (LATE EOCENE) OF SOUTHERN CHINA REVEALS AN ASIAN ORIGIN FOR THE ENIGMATIC NORTH AMERICAN PRIMATE *EKG MOWECHASHALA*
- B19** K. Miller, K. Tietjen, K. Beard DENTAL TOPOGRAPHY AND ENAMEL THICKNESS ILLUMINATE THE DIETARY ADAPTATIONS OF EOCENE PAROMOMYIDAE (MAMMALIA: PRIMATOMORPHA) FROM ELLESMERE ISLAND, ARCTIC CANADA
- B20** J. Grimes, R. Terry THE LONG AND SHORT OF IT: DYNAMIC WAYS IN WHICH SMALL-MAMMALS RESPOND *IN-SITU* TO ENVIRONMENTAL GRADIENTS IN TIME AND SPACE
- B21** A.W. Peng, S.S. Hopkins AN INVESTIGATION OF CENOZOIC LATITUDINAL DIVERSITY GRADIENTS FROM A MORPHOLOGICAL PERSPECTIVE: A CASE STUDY IN NORTH AMERICAN RODENTS
- B22** B. Heisler EARLY ORIGINS OF THE GENUS *HOMO*: TAXONOMIC AND PHYLOGENETIC ASSESSMENT OF KNM-ER 5431
- B23** N.E. Loughlin, D.L. Fox ASSESSING GRADIENTS IN NORTH AMERICAN MAMMALIAN FUNCTIONAL DIVERSITY ASSOCIATED WITH GEOGRAPHY AND CLIMATE

- B24** **A.M. Lawson, T.J. Hillard, A.W. Peng** MAMMALIAN EVOLUTION IN RESPONSE TO CLIMACTIC AND TECTONIC DRIVERS AT THE EOCENE-OLIGOCENE BOUNDARY IN THE VALLEY OF LAKES, MONGOLIA
- B25** **J.R. Claytor, E.A. Armstrong, K. Sanderson, A. Schauer, G.P. Wilson Mantilla** PRELIMINARY ANALYSIS OF CLIMATIC CONDITIONS AND MAMMALIAN DIETARY INFERENCES ACROSS THE BRIDGERIAN NALMA
- B26** **B. Carrasco-Cazares, P. Tandinco, J. Cohen, M. Balisi, W.J. Binder** DOES SIZE REALLY MATTER? A TAPHONOMIC COMPARISON OF SMALL AND LARGE MAMMALS AT RANCHO LA BREA

WEDNESDAY – SATURDAY, NOVEMBER 2-5, 2022
EDUCATION AND OUTREACH POSTER SESSION
MEETING ROOM FRONTENAC

Authors must be present from 4:30 – 6:30 p.m. on Saturday, November 5

- B27** **R.E. Narducci** CONNECTING RESEARCHERS WITH THEIR COMMUNITIES: IMPLEMENTATION OF AN INNOVATIVE THEMED EXHIBIT AT THE FLORIDA MUSEUM OF NATURAL HISTORY
- B28** **S.M. Lukowski, K. Greer** FOSSILS AND FIFTH GRADE: PROFESSIONAL DEVELOPMENT TO IMPROVE TEACHING AND LEARNING
- B29** **A.K. Hastings, J. Holm, E. Stallnick** ESTABLISHING A STATE FOSSIL FOR MINNESOTA (USA)
- B30** **J.M. Northover** TRENDING ON TIKTOK - THE POTENTIAL FOR PALEONTOLOGY EDUCATION AND OUTREACH ON THE WORLD'S FASTEST GROWING SOCIAL MEDIA PLATFORM
- B31** **R.J. Gay, A. Ferguson, X.A. Jenkins, B.R. Peacock, E. Volmer, T. Gomes** HANDS-ON WITH 3D - BUILDING MORE THAN STATIC DISPLAYS WITH 3D PRINTING TECHNOLOGY
- B32** **D. DeNeve Weeks, E.L. Lindsey, M. Porter, G. Sinatra, I. Herrick, B. Nye, D. Nelson, B. Swartout** TAR AR: RESEARCHING THE EFFECTIVENESS OF AUGMENTED REALITY ACTIVITIES FOR VISITOR LEARNING AT LA BREA TAR PITS
- B33** **B.E. Christison, M.G. Thompson, K. Emery** PALAEOPOEMS: HIGHLIGHTING POETRY AS SCIENCE COMMUNICATION IN A FREE ONLINE ARCHIVE
- B34** **R.J. Haupt, S.G. Strait** WILD, WONDERFUL, AND UNINFECTED: LESSONS LEARNED RUNNING IN-PERSON STEM DAY CAMPS DURING A GLOBAL PANDEMIC IN URBAN AND RURAL WEST VIRGINIA
- B35** **E.L. Bamforth, J.R. Milligan** FOSSIL FEVER: PALEONTOLOGY AND PARTNERSHIP IN GRASSLANDS NATIONAL PARK, SASKATCHEWAN, CANADA
- B36** **T. Rodrigues, L. Oliveira-Ciabati, E. Holanda, A. Figueiredo, P. Dentzien-Dias, A.S. Hsiou** ABUSE, HARASSMENT, AND DISCRIMINATION ARE FREQUENT ETHICAL ISSUES AMONG BRAZILIAN PALEONTOLOGISTS: A CALL FOR ROBUST D.E.I. POLICIES
- B37** **N.G. Spano, L. White, S. Loeffler** WHERE THE WILD THINGS WERE: AN ONLINE INTERACTIVE ATLAS OF CHARISMATIC ANIMAL LOSSES FROM THE PLEISTOCENE THROUGH TODAY
- B39** **S.K. Drumheller, M.R. Limbeck, K.T. Rearden** TACKLING COMPLEX TOPICS IN THE CLASSROOM USING GAMIFICATION WITH CLIMATE CHANGE: THE BOARD GAME

WEDNESDAY – SATURDAY, NOVEMBER 2-5, 2022
PREPARATORS' POSTER SESSION
MEETING ROOM FRONTENAC

Authors must be present from 4:30 – 6:30 p.m. on Thursday, November 3

- B42** **F.S. Huang, B. Shipps, B.R. Peacock** A METHOD FOR SEPARATING THE RHAMPHOTHECA FROM THE SKULL IN TURTLES THAT KEEPS BOTH BONE AND KERATIN INTACT.
- B43** **J. Miller-Camp** DUAL OSTEOLOGY GUIDE/WORKFLOWS AS AN ANSWER TO SEVERAL MUSEUM COLLECTION PROBLEMS
- B44** **N.E. Peters, B.J. Hart-Farrar, E. Snively** VIRTUAL REALITY AIDED RECONSTRUCTION AND IMMERSIVE INTERNAL ANATOMICAL VISUALIZATION OF VERTEBRATE FOSSILS

- B45** **J. Sweder** BE PREPARED: ADVANTAGES OF IMPLEMENTATION OF SEVERAL FOSSIL PREPARATION TECHNIQUES IN THE PIPESTONE CREEK BONEBED, A CRETACEOUS WAPITI FORMATION LOCALITY
- B46** **S. Potze** A COMPARATIVE INVESTIGATION OF ASPHALTIC FOSSIL PREPARATION FROM THREE BREA LOCALITIES: CALIFORNIA, ECUADOR & TRINIDAD
- B47** **C.A. Sullivan, N. Fox** A CALL FOR STANDARDIZATION OF DESTRUCTIVE ANALYSIS POLICIES

WEDNESDAY AFTERNOON, NOVEMBER 2, 2022
REGULAR POSTER SESSION 1
MEETING ROOM FRONTENAC

Authors must be present from 4:30 – 6:30 p.m. on Wednesday, November 2

- B50** **E.C. Watt, R.N. Felice, A. Goswami** TRENDS TOWARDS DECREASING MANDIBULAR COMPLEXITY THROUGH TIME IN AMPHIBIANS AND STEM TETRAPODS
- B51** **L. DeHaan, M. Friedman** A NEO - PALEONTOLOGICAL PERSPECTIVE ON THE MORPHOLOGICAL DIVERSIFICATION OF CARANGARIAN FISHES (JACKS, FLATFISHES, BILLFISHES, AND ALLIES)
- B52** **A. Murray, R.B. Holmes** PHYLOGENY AND BIOGEOGRAPHY OF THE SNAKEHEAD FISHES (TELEOSTEI: ANABANTOMORPHA: CHANNIDAE)
- B53** **W.M. Itano** A NEW SPECIES OF *CYPRIPEDIODENS* (CHONDRICHTHYES, PETALODONTOFORMES, JANASSIDAE) FROM THE LATE MISSISSIPPIAN OF ALABAMA, USA
- B54** **K. Shimada, R. Boessenecker, V. Perez, B. Kent** NEW GEOGRAPHIC AND STRATIGRAPHIC OCCURRENCES OF THE ENIGMATIC EXTINCT LAMNIFORM SHARK, *MEGALOLAMNA* (LAMNIFORMES: OTODONTIDAE), FROM THE EASTERN USA
- B56** **M. Amadori** TRACKING THE “KRAKEN-KILLER”: RISE AND FALL OF CRETACEOUS ENIGMATIC DUROPHAGOUS SHARK *PTYCHODUS* (ELASMOBRANCHII, PTYCHODONTIDAE)
- B58** **O.A. Goodchild, R. Cicariello, E.B. Daeschler** A NEW DWARF ONYCHODONTID FISH FROM THE LATE DEVONIAN OF THE CANADIAN ARCTIC
- B59** **D.M. Leong, J. Liu** THE CEPHALIC LATERAL LINE SYSTEM OF MARINE TETRAPODOMORPHS FROM THE MIDDLE DEVONIAN, RED HILL, NEVADA
- B60** **S. Chakravorti** UNIQUELY PRESERVED NEW FAMILY OF TEMNOSPONDYL FAUNA RECOVERED FROM THE MIDDLE TRIASSIC OF INDIA
- B61** **C.P. Bohus, J.D. Pardo, J.K. O'Connor, A. Mann, J. Devera** NEW TETRAPOD FOSSILS AND GEOLOGY OF THE MISSISSIPPIAN RED BED DEPOSITS NEAR GOREVILLE, SOUTHERN ILLINOIS
- B62** **T. Reinecke** DATA FROM EXTANT TETRAPODS HIGHLIGHT THE POTENTIAL FOR TRABECULAR BONE ARCHITECTURE AS A PROXY FOR POSTURE AND LOCOMOTOR ECOLOGY IN EXTINCT TAXA
- B63** **T. Maho, S. Maho, D. Scott, R. Reisz** EXCEPTIONALLY HIGH RATES OF TOOTH DEVELOPMENT AND REPLACEMENT IN EARLY PERMIAN HYPERCARNIVORE REVEAL HIDDEN DENTAL COMPLEXITY AMONG EARLY AMNIOTES
- B64** **D.J. Serratos** AN UNUSUAL METHOD FOR FOSSIL CONSERVATION EFFORT WHILE MAKING PALAEONTOLOGICAL FIELD EXPERIENCES MORE SUSTAINABLE AND INCLUSIVE ALONG THE BAY OF FUNDY, NOVA SCOTIA, CANADA
- B65** **WITHDRAWN**
- B66** **R. Uematsu, K. Tanaka, S. Kozu, S. Isaji, S. Shimojima** TURTLE AND THEROPOD EGG SHELLS FROM THE HAUTERIVIAN TO BARREMIAN OF OKURODANI FORMATION, NORTHERN CENTRAL JAPAN
- B67** **C. Plouffe, K. Brink, A. Hatcher, J. Campbell** A PARTIAL *DOLICHORHYNCHOPS OSBORNII* SKELETON (PLESIOSAURIA, POLYCOTYLIDAE) WITH ASSOCIATED STOMACH CONTENTS FROM THE PIERRE SHALE (LOWER CAMPANIAN) OF SOUTHWESTERN MANITOBA

- B68** M.P. Sodano, B. Kligman, M. Stocker, A. Marsh, W.G. Parker, S.J. Nesbitt A NEW DREPANOSAUR UNGUAL MORPHOTYPE FROM THE SONSELA MEMBER OF PETRIFIED FOREST NATIONAL PARK
- B69** A.A. Rock, D. D'Amore, T.L. Campbell, A. Herrera-Martinez, J.D. Daza SEBEK IN THE AMERICAS: TOOTH VARIATION IN *LANGSTONIA HUILENSIS* (SEBECIDAE: NOTOSUCHIA CROCODYLOMORPHA) WITH COMMENTS ON PREDATION STRATEGY
- B70** T.W. LaBarge, J.K. Njau TAPHONOMY AND ICHNOLOGY OF NILE CROCODILE FEEDING BEHAVIOR
- B71** B.R. Peacock, L. Krumenacker, A. Ferguson, X.A. Jenkins A LATERALLY EXTENSIVE AVIAN ROOKERY FROM THE DELTA FACIES OF THE GREEN RIVER FORMATION, SPANISH FORK CANYON, UTAH COUNTY, UTAH
- B72** T.L. Green, A. Watanabe, J. Ng, S. Chariwala, T. Goldblatt, P. Gignac 3D CRANIAL IMAGING IS THE SWAN SONG FOR THE CASSOWARY CASQUE AS A VOCAL RESONATOR
- B73** R. Takasaki, Y. Kobayashi DIET-STOMACH INTERACTION AMONG NEORNITHINES AND ITS IMPACT ON THE NEORNITHINE EVOLUTIONARY HISTORY
- B74** M. Kirchner-Smith VULTURE FEEDING GUILDS FROM THE LATE PLEISTOCENE TO THE MODERN DAY: A GEOMETRIC MORPHOMETRIC APPROACH
- B76** B.H. Breithaupt, N.A. Matthews, R.K. Hunt Foster LEFT BUT NOT FORGOTTEN: USING PHOTOGRAMMETRY FOR LONG-TERM PRESERVATION AND MANAGEMENT OF IN SITU PALEONTOLOGICAL RESOURCES: STORIES OF THE GOOD, THE BAD, AND THE UGLY
- B77** J.B. McHugh, S.K. Drumheller ASSESSING TAPHONOMIC ACTIVITY AMONG VERTEBRATE REMAINS FROM TWO UPPER JURASSIC MORRISON FORMATION FOSSIL SITES: BONE CABIN AND MYGATT-MOORE QUARRIES
- B78** I.D. Broxson, J.A. Case RECONSTRUCTING THE ECOLOGICAL RELATIONSHIPS OF LATE CRETACEOUS ANTARCTIC DINOSAURS AND HOW FUNCTIONAL TOOTH MORPHOLOGY INFLUENCED ECOLOGICAL NICHE AND DIET AMONG BASAL ORNITHOPOD DINOSAURS
- B79** S. DeNarie, C. Forster, J. Clark TAKING SYSTEMATICS BY THE HORNS: TOWARDS A FULLY SAMPLED PHYLOGENY OF CERATOPSIA
- B80** S. Oyabu, Y. Kobayashi REDESCRIPTION OF THE NODOSAURID (DINOSAURIA:ORNITHISCHIA) SKULL SPECIMEN FROM THE MIDDLE CRETACEOUS HIKAGENOSAWA FORMATION (ALBIAN-CENOMANIAN) OF HOKKAIDO, JAPAN.
- B81** J.E. D'Angelo A REEVALUATION OF THE PHYLOGENETIC RELATIONSHIPS OF THE CONTROVERSIAL CENTRAL ASIAN SAUROPOD *DZHARATITANIS KINGI*
- B82** T.L. Adams, D. Price, C. Davis, J. Newman, D.J. Lehrmann, A.A. Lehrmann, D. Altiner, A. Godet, J. Sharpe, M. Suarez NO SWIMMING DINOSAURS HERE: NEW INSIGHTS ON MANUS-DOMINATED DINOSAUR TRACKS FROM THE MAYAN DUDE RANCH IN BANDERA, TEXAS
- B83** J.A. Whitlock, J.P. Garderes, P.A. Gallina AN UNRECOGNIZED BOUNTY: THE FOURTH DICRAEOSAURID SAUROPOD FROM THE MORRISON FORMATION (LATE JURASSIC) OF NORTH AMERICA
- B84** T. Chinzorig, T. Cullen, G. Phillips, L.E. Zanno NEW TYRANNOSAUROID MATERIALS FROM THE UPPER CRETACEOUS EUTAW FORMATION OF MISSISSIPPI, USA
- B85** W.J. Freimuth, L.E. Zanno NEW CRANIODENTAL MATERIAL OF THE THERIZINOSAURIAN *FALCARIUS UTAHENSIS*
- B86** L. Czepinski A SECOND INDIVIDUAL OF DROMAEOSAURID *SHRI DEVI* FROM THE LATE CRETACEOUS BARUUNGOYOT FORMATION OF MONGOLIA
- B87** C.J. Hohman, J.G. Napoli, D. Varricchio NEW DATA ON THE ANATOMY AND IDENTITY OF MOR 660 (THEROPODA: DROMAEOSAURIDAE)
- B88** E.A. Shirley, D.C. Fisher, A.N. Rountrey, M.D. Cherney, S.G. Beld TUSK GROWTH AND PRESERVATIONAL SETTING OF AN LGM MAMMOTH AT THE MARGIN OF THE ICE SHEET

- B90** C.M. Peredo, L. Raley, L. DeHaan, C.D. Marshall ARE PINNIPEDS HOMODONT? SHAPE ANALYSES SHOWS A BROAD DIVERSITY OF PINNIPED CHEEK TEETH MORPHOLOGIES.
- B91** M. Boisville, N. Chatar, O. Lambert, L. Dewaele SEXUAL DIMORPHISM IN THE WALRUS MANDIBLE: COMPARATIVE DESCRIPTION AND GEOMETRIC MORPHOMETRICS
- B92** R. Messec, J.S. Keller, J. Moore MEASUREMENT PROTOCOL INFLUENCES INTRASPECIFIC MOLAR VARIATION IN MODERN AND FOSSIL RODENTS
- B93** T. Harper, R. MacPhee INTERNAL PETROSAL ANATOMY OF TWO EARLY MIOCENE LITOPTERNS
- B94** A.F. Schwartz, L.R. DeSantis, E. Mueller, R. Scott COMPARING DIETS OF THE MESONYCHID *DISSACUS* AND BLACK-BACKED JACKAL *CANIS MESOMELAS* USING DENTAL MICROWEAR TEXTURE ANALYSIS
- B95** D. Flores, W. Godwin, C.J. Bell, P.J. Lewis IDENTIFICATION OF THE PLEISTOCENE FAUNA FROM MCFADDIN BEACH, TEXAS
- B96** A.A. Brink, R. Cifelli, S.L. Wick LATE CRETACEOUS IN THE BIG BEND REGION OF TEXAS: THE SOUTHERNMOST RECORD OF SPALACOLESTINE "SYMMETRODONT" IN NORTH AMERICA
- B97** S.L. Shelley, P. (PalM) THE PHYLOGENY OF PALEOCENE MAMMALS AND THE EVOLUTION OF PLACENTALIA
- B98** K.R. Selig, K. Jäger, B. Davis, J. Meng THE DEVELOPMENT OF MOLAR COMPLEXITY AND THE EVOLUTION OF THE TRIBOSPHEMIC MOLAR
- B99** J.A. Case, T. Wheat, I.D. Broxson TURNOVER OF TERRESTRIAL HERBIVORES (DIPROTODONTIA: MARSUPIALIA) IN THE LATE OLIGOCENE, ETADUNNA FORMATION, SOUTH AUSTRALIA
- B100** T.C. Wheat, J.A. Case A LATEST OLIGOCENE OCCURRENCE OF FEATHER-TAIL POSSUMS (ACROBATIDAE: MARSUPIALIA) FROM THE WIPAJIRI FORMATION, SOUTH AUSTRALIA
- B101** N.C. Cochran CRANIAL AND POSTCRANIAL ONTOGENY OF THREE SPECIES OF *DIMETRODON* SHOWS SIZE DOES NOT CORRELATE WITH MATURITY
- B102** S.S. Strassberg, K.D. Angielczyk PINEAL FORAMEN VARIATION AS A WINDOW INTO SENSORY EVOLUTION, CONVERGENCE OF MAMMAL-LIKE CRANIAL TRAITS, AND MAJOR LINEAGE DIVERGENCES IN PRE-MAMMALIAFORM SYNAPSIDA

THURSDAY MORNING, NOVEMBER 3, 2022
ROMER PRIZE SESSION
MEETING ROOM METRO CENTRE
MODERATORS: Ken Angielczyk and Pia Viglietti

- 8:00** A.R. Reynolds *SMILODON FATALIS* WAS SEXUALLY DIMORPHIC AND SOCIAL, AS REVEALED BY OSTEOHISTOLOGY
- 8:15** S.J. ElShafie CROCODYLIFORM BODY SIZE TRACKS PRECIPITATION AND LIZARD BODY SIZE TRACKS LOCAL TEMPERATURE OVER DEEP TIME INTERVALS
- 8:30** R. Ely INTRODUCING THE EARLY HIGH DISPARITY PHYLOGENETIC COMPARATIVE MODEL, WITH APPLICATIONS TO BODY SIZE EVOLUTION IN WHALES (MAMMALIA:CETACEA) AND ICHTHYOSAURS (REPTILIA:ICHTHYOSAURIFORMES)
- 8:45** S.L. Olroyd ALLOMETRY OF BONY SOUND RECEPTION STRUCTURES AND EVIDENCE FOR A MANDIBULAR EAR IN NON-MAMMALIAN SYNAPSIDA
- 9:00** E. Lessner ORIGIN OF ENHANCED CRANIAL TACTILE SENSATION IN CROCODYLIFORMS
- 9:15** B.W. Griffin HOW DO PTEROSAURS LAUNCH?: MODELLING MUSCLE MOMENTS IN AN ORNITHOCHEIRAEAN MODEL
- 9:30** J.A. Schwab ENDOCRANIAL SENSORY SYSTEMS REVEAL ECOMORPHOLOGICAL ADAPTATIONS TO A SECONDARILY AQUATIC LIFESTYLE IN THALATTOSUCHIAN CROCODYLOMORPHS

- 9:45 **A.R. Manafzadeh** JOINT SURFACE INTERACTIONS DISTINGUISH DINOSAURIAN LOCOMOTOR POSES
- 10:15 **A.K. Parker** TRACING COORDINATED TRENDS AND DRIVERS OF MAXIMUM BODY SIZE IN CENOZOIC TERRESTRIAL VERTEBRATES
- 10:30 **P.Z. Barrett** THE EVOLUTION OF FELIFORM (CARNIVORA) CRANIAL SHAPE: THE FRUITFUL CHANNELING OF EXTREME ECOLOGY
- 10:45 **K. Schroeder** SINKING TEETH INTO ONTOGENY: DENTAL MICROWEAR TEXTURAL ANALYSIS QUANTIFIES DIETARY NICHE PARTITIONING BETWEEN AND WITHIN TYRANNOSAURS
- 11:00 **L.E. Roberts** THE ECOLOGICAL, MORPHOLOGICAL, AND DEVELOPMENTAL DRIVERS OF AXIAL SKELETON EVOLUTION IN REPTILIA: RECOVERING HISTORIES OF SKELETAL COMPLEXITY IN THE MOST DIVERSE TETRAPOD CLADE
- 11:15 **R. Engelman** A DEVONIAN FISH TALE: A NEW METHOD OF BODY LENGTH ESTIMATION IN PLACODERMS SUGGESTS MUCH SMALLER SIZES FOR THE FAMENNIAN ARTHRODIRE *DUNKLEOSTEUS TERRELLI*
- 11:30 **J.G. Napoli** DISENTANGLING ONTOGENY FROM PHYLOGENY IN THE ARCHOSAUR CRANIUM
- 11:45 **V. Buffa** PERMIAN PILOTS: FLYING WITH THE FIRST GLIDING REPTILES
- 12:00 **Y. Haridy** MINERAL METABOLISM AND THE ORIGIN OF CELLULAR BONE

THURSDAY MORNING, NOVEMBER 3, 2022
TECHNICAL SESSION 5: AMPHIBIANS & EARLY REPTILES
MEETING ROOM METRO EAST
MODERATORS: Xavier Jenkins and Jason Pardo

- 8:00 **T.A. Stewart, J. Lemberg, E. Hillan, I. Magallanes, E.B. Daeschler, N. Shubin** THE AXIAL SKELETON OF *TIKTAALIK ROSEAE*
- 8:15 **M.R. Whitney, P.J. Bishop, J. Bevitt, S. Hocknull, S.E. Pierce** LIFE HISTORY FEATURES OF THE GONDWANAN EARLY TETRAPOD *OSSINODUS* REVEALED FROM OSTEO- AND ODONTOHISTOLOGICAL SYNCHROTRON DATA
- 8:30 **J.D. Pardo, A. Mann** EXCEPTIONALLY PRESERVED LARVAL STEM TETRAPODS FROM MAZON CREEK
- 8:45 **B. Igielman, R. Benson** NEW ANATOMICAL DATA OF THE ENIGMATIC CARBONIFEROUS TETRAPOD *WESTLOTHIANA LIZZAE* FROM SYNCHOTRON PHASE-CONTRAST CT REVEALS RETENTION OF PRIMITIVE CHARACTERS CLOSE TO THE AMNIOTE CROWN
- 9:00 **T. Hirasawa, Y. Hu, K. Uesugi, M. Hoshino, M. Manabe, S. Kuratani** CRANIAL MORPHOLOGY OF *PALAEOSPONDYLUS*
- 9:15 **D.E. Korneisel, S. Hassan, H. Maddin** ON THE HOMOLOGY OF THE AMPHIBIAN 'ODONTOID PROCESS'
- 9:30 **D. Marjanović, H. Maddin, J. Olori, M. Laurin** *CHINLESTEGOPHIS* AND THE ORIGIN OF CAECILIANS (GYMNOPHIONA, LISSAMPHIBIA): A CASE STUDY IN PHYLOGENETICS
- 9:45 **B. Gee, C. Sidor** SLEUTHING THE SMALL: THE SECRETS OF SMALL-BODIED STEREOSPONDYLS FROM THE TRIASSIC OF ANTARCTICA AND THE INFLUENCE OF SIZE DISPARITY ON INFERENCE OF TEMNOSPONDYL PALEOBIOLOGY
- 10:15 **C. So** TESTING FOR COMPLEX BODY SIZE EVOLUTION IN TEMNOSPONDYLS AND MODERN AMPHIBIANS WITH PHYLOGENETIC COMPARATIVE METHODS
- 10:30 **A. Lemierre** PANCAKE FROG IN THE BOG: CHRONOLOGY AND PALEOBIOGEOGRAPHY OF PIPIDAE (ANURA) DIVERSIFICATION
- 10:45 **K.M. Jenkins, C.M. Gordon, J.G. Napoli, B.S. Bhullar** VISUALIZING AN ELUSIVE HOLOTYPE: THE CRANIAL OSTEOLOGY OF *BOLOSOURUS MAJOR* (PARAREPTILIA: BOLOSOURIDAE)

- 11:00** **H. Sues, M. Ezcurra** ANATOMY AND PHYLOGENETIC POSITION OF THE BIZARRE, LARGE-HEADED REPTILE *SPHODROSAURUS PENNSYLVANICUS* (UPPER TRIASSIC; PENNSYLVANIA, USA)
- 11:15** **X.A. Jenkins, B.R. Peacock, D. Ford, E. Griffiths, M. Elliott, G. Jeppson, J. Choiniere, R. Benson** DESCRIPTIONS OF *MILLERETTA RUBIDGEI* AND *MILLEROPSIS PRICEI* (AMNIOTA, PARAREPTILIA) USING HIGH-RESOLUTION NCT WITH IMPLICATIONS FOR THE MONOPHYLY OF PARAREPTILES
- 11:30** **A. Sanchez** JUVENILE POSTCRANIAL SKELETAL ELEMENTS OF THE EARLY PERMIAN EUREPTILIAN REPTILE *LABIDOSAURUS*: NEW INFORMATION ON SKELETAL ONTOGENY OF BASAL CAPTORHINID REPTILES
- 11:45** **L. Legendre, S. Choi, J. Clarke** WALKING ON EGGSHELLS: REEVALUATING THE ‘HARD/SOFT’ DICHOTOMY OF REPTILE EGG SHELL MICROSTRUCTURE IN A PHYLOGENETIC CONTEXT
- 12:00** **S.S. Sumida, G. Albright, J. Jung** A NEW GENUS OF CAPTORHINID REPTILE (AMNIOTA: EUREPTILIA) FROM THE LOWER PERMIAN HENNESSEY FORMATION OF CENTRAL OKLAHOMA: DENTAL HOMOPLASY IN THE FAMILY CAPTORHINIDAE AND THE EARLIEST KNOWN EXAMPLE OF MINITURIZATION IN A BASAL AMNIOTE

THURSDAY MORNING, NOVEMBER 3, 2022
PREPARATORS SESSION
MEETING ROOM METRO WEST
MODERATORS: Matthew Miller and Vanessa Rhue

- 8:00** **A. Pérez-Ramos, D.S. Prieto, M. Burgos, F. Esteban Ortega, M. Bastir** VIRTUAL RECONSTRUCTION OF THE PARANASAL SINUS AND NASAL AIRWAYS OF THE GIBRALTAR-1 *HOMO NEANDERTHALENSIS* SKULL.
- 8:15** **A.A. Fike, C. Knight, M. Triebold, A.E. Maltese** BASIC FIELD JACKETING TECHNIQUES - A CASE STUDY OF METHODS USED IN THE NIOBRARA FORMATION OF KANSAS
- 8:30** **I.D. Browne, A. Claxton, A. Danison, L.M. Witmer** 3D PRINTING POP-TOGETHER OSTEOLOGICAL MODELS: A DESIGN AND FABRICATION WORKFLOW
- 8:45** **M. Pinsdorf, A. Behlke, S. Jabo, P. Kroehler, J. Nakano** STABILIZATION AND CRATING FOR TRANSPORT OF A LOANED HOLOTYPE *TRICERATOPS* SKULL
- 9:00** **A. Shinya, C. Van Beek, P. Makovicky** PLASTER FIELD JACKETS USING AIR FILTER MEDIA: AN ALTERNATIVE TO TRADITIONAL BURLAP AND PLASTER JACKETS
- 9:15** **WITHDRAWN**
- 9:30** **A. Behlke** THE USE OF SODIUM POLYTUNGSTATE TO ACCELERATE THE PICKING OF VERTEBRATE MICROFOSSILS: A CASE STUDY FROM THE ELLISDALE FOSSIL SITE
- 9:45** **S.R. Davison, L.E. Wilson** EXAMINING DATA COLLECTION, ARCHIVING PROTOCOLS, AND DATA ACCESSIBILITY IN FOSSIL PREPARATION LABS

THURSDAY MORNING, NOVEMBER 3, 2022
NEW METHODS SESSION
MEETING ROOM METRO WEST
MODERATORS: David Polly and Amber Whitebone

- 10:15** **S. Brougham, T. Frauenfelder, N. Campione** A NOVEL PHYLOGENY-INFORMED MACHINE LEARNING METHOD FOR IMPROVED ACCURACY IN TAXONOMIC CLASSIFICATION
- 10:30** **L. Hart, N. Campione, M. McCurry** METHODS OF BODY MASS ESTIMATION IN TEMNOSPONDYL AMPHIBIANS
- 10:45** **A. Schröder** BENCHTOP MICRO-X-RAY FLUORESCENCE: AN EXCITING TOOL FOR TAXONOMIC PURPOSES WITHIN PALEONTOLOGY
- 11:00** **P. Polly** SPATIAL PROCESSES, STATISTICAL MODELS, AND VERTEBRATE EVOLUTION IN A CHANGING ENVIRONMENT

- 11:15** **A. Whitebone, N. Campione, P. Bell** A NEW TOOL FOR DESCRIBING FOSSIL BONE MICROSTRUCTURE: LIQUID CRYSTAL CROSS-POLARIZED LIGHT MICROSCOPY AND THE IDENTIFICATION OF MUSCLE ATTACHMENTS AND OTHER STRUCTURES
- 11:30** **I. Wilenzik, R. Pyron** ANCESTRAL RANGE ESTIMATION OF THE ORDER SQUAMATA USING FOSSIL-INFORMED PHYLOGENIES AND A GEOGRAPHICALLY-INFORMED MODEL
- 11:45** **L. Marchetti, M.J. MacDougall, S. Seifert, J. Fröbisch** MATCHING MORPHOLOGICAL CHARACTERS OF FOOTPRINTS AND SKELETONS IN THE LIGHT OF EARLY TETRAPOD EVOLUTION: EXAMPLES FROM THE BROMACKER LOCALITY (GERMANY, EARLY PERMIAN)
- 12:00** **K.N. Dollman, V. Fernandez, F. Ciancosi, A. Buisson, P. van Vaerenbergh, E. Boller, J. Vieux, C. Jarnias, V. Beyrand, S. Zabler** A NEW BEAMLINE, BM18, AT THE EUROPEAN SYNCHROTRON AND RADIATION FACILITY AND ITS APPLICATIONS FOR PALAEOLOGY

THURSDAY AFTERNOON, NOVEMBER 3, 2022
TECHNICAL SESSION 6: DINOSAUR MACROEVOLUTION/MACROECOLOGY
MEETING ROOM METRO CENTRE
MODERATORS: Thomas Cullen and Kat Schroeder

- 1:45** **J.D. Gardner, J.P. Wilson, H.M. Flora, X. Xu, C. Organ** FUNCTIONAL INNOVATIONS DROVE EVOLUTIONARY RATES AND DIVERSIFICATION IN DINOSAURS
- 2:00** **T. Cullen, S. Zhang, H. Maddin, B. Cousens** USING BIOGEOCHEMICAL PROXIES TO TEST HYPOTHESES OF FOOD WEB STRUCTURE AND NICHE PARTITIONING IN FLOODPLAIN ECOSYSTEMS OF THE CAMPANIAN BELLY RIVER GROUP OF CANADA
- 2:15** **A.A. Chiarenza, J. García-Girón, J. Alahuhta, D.G. DeMar, J. Heino, P.D. Mannion, T.E. Williamson, G.P. Wilson Mantilla, S.L. Brusatte** SHIFTS IN TROPHIC ARCHITECTURE AND ECOSPACE STABILITY DETERMINING SURVIVORSHIP AND EXTINCTION AT THE END-CRETACEOUS
- 2:30** **J.T. Voris, D.K. Zelenitsky, F. Therrien, R.C. Ridgely, L.M. Witmer** ENDOCRANIAL ONTOGENY IN *GORGOSAURUS LIBRATUS* (TYRANNOSAURIDAE) REVEALS NEW INFORMATION ON BRAIN EVOLUTION IN THEROPODS
- 2:45** **C. Griffin, N.G. Pezzoni, R. Pintore, R.B. Irmis, N.D. Smith, A. Turner, A. Marsh, S.J. Nesbitt** FEMORAL ONTOGENY OF THE TRIASSIC SAURISCHIAN *TAWA HALLAE* SUGGESTS THAT NEOTHEROPOD HINDLIMBS EVOLVED VIA SHIFTS IN ONTOGENETIC TIMING
- 3:00** **G.F. Funston, S. Williams, J. Mathews, H. Woodward, T. Carr, P. Currie, S.L. Brusatte** TYRANNOSAUR FORELIMB REDUCTION IS NOT LINKED TO LARGE BODY SIZE
- 3:15** **M.D. D'Emic, P.M. O'Connor, R.S. Sombathy, I. Cerda, T. Pascucci, D. Varricchio, D. Pol, A. Dave, R. Coria, K. Curry Rogers** THE EVOLUTION OF GIGANTISM AND MINIATURIZATION IN THEROPOD DINOSAURS
- 3:30** **T.R. Holtz** BREAKING THE MACROPREDATORY MOLD: NON-PREDATORY THEROPOD DINOSAUR ECOMORPHOLOGY AND MACROEVOLUTION
- 3:45** **K. Schroeder, N.E. Van Vranken** MAKING A RUN FOR IT: THE IMPACT OF FLIGHT-ADAPTIVE TRAITS ON NICHE PARTITIONING IN CARNIVOROUS NON-AVIAN THEROPODS
- 4:00** **WITHDRAWN**

THURSDAY AFTERNOON, NOVEMBER 3, 2022
TECHNICAL SESSION 7: PALEOGENE MAMMALS & PRIMATES & CARNIVORA
MEETING ROOM METRO EAST
MODERATORS: Ornella Bertrand and Isaac Magallanes

- 1:45 **E. Newham, P.G. Gill, P. Brewer, J. Schultz, K. Jaeger, I.J. Corfe, T. Martin** CEMENTOCHRONOLOGY REVEALS THE EVOLUTION OF LIFE HISTORY AMONGST THE EARLIEST MAMMALS
- 2:00 **I. Magallanes, K. Beard, Z. Luo** A NEW DRYOLESTOID SPECIMEN FROM THE LATE JURASSIC PROVIDES NEW INSIGHTS ON THE SIGNIFICANCE OF TOOTH ROOT STRUCTURE THROUGHOUT MAMMAL HISTORY
- 2:15 **M.R. Borths, S.F. Al-Ashqar, H.M. Sallam, E.R. Seiffert** THE OLDEST HYPERCARNIVORE (PLACENTALIA, MAMMALIA, HYAENODONTA) FROM THE FAYUM DEPRESSION, EGYPT
- 2:30 **O.C. Bertrand, S.L. Shelley, T.E. Williamson, J.R. Wible, S.G. Chester, L.T. Holbrook, T.R. Lyson, J. Meng, T. Smith, S.L. Brusatte** VESTIBULAR SENSITIVITY AND LOCOMOTOR BEHAVIOR IN EARLY PALEOCENE MAMMALS
- 2:45 **B. Witt, J.A. Meachen** A REASSESSMENT OF *MIRACINONYX TRUMANI* AND *PUMA CONCOLOR* OCCURRENCES IN THE FOSSIL RECORD OF PLEISTOCENE NORTH AMERICA
- 3:00 **N. Chatar, V. Fischer, Z. Tseng** MULTI-GAPE ANGLE 3D BIOMECHANICAL MODELLING OF THE CAT-LIKE MANDIBLE REVEALS NUANCES OF SABERTOOTH FUNCTIONAL MORPHOLOGICAL EVOLUTION
- 3:15 **M.F. Jones, N. Simmons, K. Beard** RELATIONSHIP OF NYCTITHERES (MAMMALIA, NYCTITHERIIDAE) TO BATS AND OTHER LAURASIATHERIANS
- 3:30 **J.W. Crowell, J.R. Wible, S.G. Chester** AUDITORY REGION OF PALEOCENE *ZANYCTERIS PALEOCENUS* AND THE RELATIONSHIP OF PICRODONTIDS TO PLESIADAPIFORMS
- 3:45 **R.F. Kay, K.L. Allen, P.E. Morse, E.C. Kirk** THE MOST COMPLETE SKELETON OF *HOMUNCULUS PATAGONICUS* (PLATYRRHINI, PRIMATES) FROM THE EARLY MIOCENE, ARGENTINA, IMPROVES ESTIMATES OF BODY SIZE AND RELATIVE ENDOCRANIAL VOLUME IN A STEM PLATYRRHINE
- 4:00 **J. Kingston, S.M. Cote, D.L. Fox, K.P. McNulty, D. Peppe, C. Stromberg, L. MacLachy** HOMINOID EVOLUTION IN OPEN WOODLAND HABITATS: EVIDENCE FROM THE EARLY MIOCENE OF UGANDA

THURSDAY AFTERNOON, NOVEMBER 3, 2022
TECHNICAL SESSION 8: EVOLUTIONARY DEVELOPMENTAL BIOLOGY
MEETING ROOM METRO WEST
MODERATORS: Emily Buchholtz and Victoria Herridge

- 1:45 **J. Atkins, A. Cantelon, N. Piekarski, J. Hanken, H. Maddin** THE EVOLUTION OF THE SKULL-NECK BOUNDARY: INSIGHTS FROM EXTANT LISSAMPHIBIANS
- 2:00 **Z.S. Morris, B.S. Bhullar** PATTERNS OF AMNIOTE PALATE DIVERSIFICATION AND CONVERGENCE
- 2:15 **B.S. Bhullar, M. Hanson, M. Fabbri, A.A. Ruebenstahl, J.K. O'Connor, M. Norell** THE ORIGIN OF THE BIRD ROSTRUM AND KINETIC APPARATUS INVOLVED EVOLUTIONARY "STOPGAP" PHASES AND WAS LINKED DEVELOPMENTALLY TO TRANSFORMATIONS IN THE AIR PASSAGE AND JAW MUSCLES
- 2:30 **R. Marek, R.N. Felice** GRABBING EVOLUTION BY THE THROAT: THE ROLE OF NECK-FORELIMB INTEGRATION IN AVIAN EVOLUTION
- 2:45 **E.A. Buchholtz, A.E. Brent, J.H. Mansfield** STERNAL EVOLUTION IN SYNAPSIDA: ELEMENT ASSEMBLY AND LOSS
- 3:00 **R.J. Asher** DENTAL DEVELOPMENT, INHIBITORY CASCADE, AND FIRST PREMOLAR HOMOLOGY IN PLACENTAL MAMMALS
- 3:15 **H. White, A. Tucker, A. Goswami** MODELLING HOW SUTURE MORPHOLOGY, COMPLEXITY, AND DEVELOPMENT DRIVES MAMMALIAN CRANIAL EVOLUTION
- 3:30 **V. Herridge, A. Goswami** TESTING THE INHIBITORY CASCADE MODEL IN ELEPHANTS

- 3:45 **A. Goswami, A. Lanzetti, E.J. Coombs, R. Portela Miguez, V. Fernandez** THE WAY TO WONKINESS: THE ONTOGENY OF ASYMMETRY IN ECHOLOCATING WHALES
- 4:00 **A. Ashbaugh, J.M. Theodor** STUDYING THE PATTERNS OF CHEEK TOOTH SHAPE COVARIATION TO BETTER UNDERSTAND THE EVOLUTION OF MOLARIZATION IN HOOFED MAMMALS

**THURSDAY AFTERNOON, NOVEMBER 3, 2022
REGULAR POSTER SESSION 2
MEETING ROOM FRONTENAC**

Authors must be present from 4:30 – 6:30 p.m. on Thursday, November 3

- B103 R.P. Winter, M. Ebert, A. López-Arbarello** A NEW CATURID (HOLOSTEI: HALECOMOPRHI) FROM THE UPPER JURASSIC OF BRUNN (BAVARIA, GERMANY)
- B105 I.S. Hutchinson, I. Brown, C. Redman, D. Varricchio, J. Moore** A NEW TERRESTRIAL-DOMINATED MICROFOSSIL ASSEMBLAGE FROM THE LATE CRETACEOUS TWO MEDICINE FORMATION OF MONTANA, U.S.A.
- B106 A.L. Wurtz, A.B. Heckert, J. Foster, R.K. Hunt Foster, J.J. Eberle** A NEW MICROVERTEBRATE ASSEMBLAGE FROM THE UPPER CRETACEOUS (EDMONTONIAN) WILLIAMS FORK FORMATION, NORTHWESTERN COLORADO, USA, AND THE TAPHONOMY OF WILLIAMS FORK FORMATION VERTEBRATES
- B107 A. DeMers, J. Hunter** META-ANALYSIS OF ORIENTATION PATCH COUNT ROTATED (OPCR) AND DIETARY INFERENCE IN TERRESTRIAL AMNIOTES
- B108 E. Patellos, B. Kligman, A. Marsh, M. Stocker, W.G. Parker, S.J. Nesbitt** QUANTIFYING VARIATION IN THE MARGINAL DENTITION OF A MALERISAURINE (ALLOKOTOSAURIA) FROM THE UPPER TRIASSIC CHINLE FORMATION OF ARIZONA SHOWS STATISTICALLY DISTINCT MORPHOLOGIES WITHIN DIFFERENT TOOTH-BEARING ELEMENTS
- B109 A.C. Henrici, D.S. Berman, A. Huttenlocker, S.S. Sumida** A NEW LATE CARBONIFEROUS (GZHELIAN) ARAEOSCELIDIAN (REPTILIA, DIAPSIDA) FROM THE BIRTHDAY BONEBED, HALGAITO FORMATION, BEARS EARS NATIONAL MONUMENT, UTAH, USA
- B110 E.D. Mooney, T. Maho, J. Bevitt, R. Reisz** AN INTRIGUING NEW DIAPSID REPTILE WITH EVIDENCE OF MANDIBULO-DENTAL PATHOLOGY FROM THE EARLY PERMIAN OF OKLAHOMA REVEALED BY NEUTRON TOMOGRAPHY
- B111 D. DeBlieux, J.I. Kirkland, E. Cowgill, T. Thomson, A. R.C. Milner, V. Santucci** SIGNIFICANT VERTEBRATE FOSSIL LOCALITIES DISCOVERED DURING PALEONTOLOGICAL RESOURCE INVENTORY OF THE TRIASSIC MOENKOPI AND CHINLE FORMATIONS AT CANYONLANDS NATIONAL PARK
- B112 V. Gold, M. Fayek, K. Brink** DENTINE OXYGEN ISOTOPES REVEAL PERIODIC FRESHWATER INCURSIONS IN MARINE REPTILES FROM THE WESTERN INTERIOR SEAWAY OF MANITOBA, CANADA
- B113 D.T. Ledesma, M.E. Kemp** CHANGES IN CENTRAL TEXAS LIZARD DIVERSITY FROM HALL'S CAVE DURING THE LATE PLEISTOCENE AND THE HOLOCENE
- B114 J. Sterli, N. Nieto, F. Degrange, E. Vlachos** TESTING THE SKULL PERFORMANCE OF THE MEIOLANIID *NIOLAMIA ARGENTINA* (TESTUDINATA) USING FINITE ELEMENT ANALYSIS
- B115 G.R. Hurlburt** OCCURRENCE OF THE PINEAL GLAND AND ARACHNOID MATER IN ALLIGATOR INDICATE AN ARACHNOID IN ALL TETRAPODS AND A PINEAL IN ALL VERTEBRATES, EXCEPTING MYXINI. CEREBROSPINAL FLUID OCCUPIES MOST OF THE BRAIN CAVITY VOLUME IN THE LARGEST ADULT ALLIGATOR
- B116 D.F. Macias, J.W. Moreno-Bernal, A. Link, A. Vanegas, R. Vanegas, A. Sandoval** A JACAREAN CAIMANINE SKELETON FROM THE MIDDLE MIOCENE OF COLOMBIA AND THE ORIGINS OF LIVING SPECTACLED CAIMANS
- B117 A.Q. Harper, A. Turner, M.D. D'Emic** NEW CROCODYLIFORM MATERIAL FROM THE CLOVERLY FORMATION (ALBIAN) OF WYOMING, USA

- B118** **A.R. Beyl, K.N. Dollman, J. Choiniere, A. Turner** INTERNAL CRANIAL ANATOMY OF *LITARGOSUCHUS LEPTORHYNCHUS* AND THE IMPLICATIONS FOR NON-CROCODYLIFORM CROCODYLOMORPHA
- B120** **J.T. Deckhut, Z. Boles** A SMALL AND UNUSUAL K/PG AVIAN TARSOMETATARSUS FROM THE CRETACEOUS-PALEOGENE HORNERSTOWN FORMATION OF NEW JERSEY
- B121** **E.J. Cruz Vega, J.K. O'Connor, M. Fabbri** TESTING HYPOTHESES REGARDING SUPER-PRECOXIAL DEVELOPMENT IN ENANTIORNITHES
- B122** **M. Pittman, P. Bell, C.V. Miller, N.J. Enriquez, X. Wang, X. Zheng, L. Tsang, Y. Tse, M. Landes, T. Kaye** ECOLOGY OF EARLY THEROPOD FLYERS REFINED BY THEIR PEDAL ANATOMY
- B123** **N.J. Enriquez, N. Campione, C. Hendrickx, C.M. Brown, P. Bell** ELEMENTAL CONSTITUENTS WITHIN FOSSILISED DINOSAUR SKIN AND THEIR POTENTIAL TO BOOST RATES OF SKIN PRESERVATION
- B124** **K. Tanaka, W. Ma, D.K. Zelenitsky, R. Chen** A DIVERSE DINOSAUR EGG ASSEMBLAGE FROM THE MID-CRETACEOUS JINHUA FORMATION, ZHEJIANG PROVINCE, CHINA
- B125** **E.R. Bender, T.A. Gates, D.C. Evans, R.M. Sullivan, T.E. Williamson** RECONSIDERING THE OSTEOLOGY AND SYSTEMATICS OF THE HADROSAURID *NAASHOIBITOSAURUS OSTROMI* (ORNITHOPODA: DINOSAURIA) FROM THE UPPER CRETACEOUS KIRTLAND FORMATION OF NEW MEXICO
- B126** **S. Finch, M.D. D'Emic** A JUVENILE SPECIMEN OF THE ORNITHOPOD DINOSAUR *TENONTOSAURUS* FROM THE LOWER CRETACEOUS OF MONTANA, U.S.A.
- B127** **C. Libke, R.C. McKellar, C. Somers** THE BONE HISTOLOGY OF *THESCÉLOSAURUS ASSINIBOENSIS* AND THE POTENTIAL UTILITY OF HISTOLOGY FOR SPECIES IDENTIFICATION
- B128** **D. Madzia, L. Czepinski** REVISED OSTEOLOGY AND PHYLOGENETIC AFFINITIES OF *AJKACERATOPS KOZMAI* FROM THE SANTONIAN (UPPER CRETACEOUS) OF HUNGARY
- B129** **J.L. Kitchener, P. Bell, N. Campione** MORPHOMETRICS AND FUNCTION OF THE ORNITHISCHIAN FEMUR AND FOURTH TROCHANTER
- B130** **F. Bertozzo, K.H. Stein, E. Varotto, A. Ruffell, E. Murphy** A PATHOLOGICAL FEMUR OF AN IGUANDONTIAN DINOSAUR WITH MEDULLARY-LIKE BONE INVOLVEMENT IN THE HEALING PROCESS
- B131** **A.D. Dyer, M.J. Powers, P. Currie** SYNCHROTRON μ CT IMAGING REVEALS "*GRAVITHOLUS ALBERTAE*" AS A MATURE END-STAGE *STEGOCERAS VALIDUM*
- B132** **J.I. Kirkland, S.K. Madsen, D. DeBlieux** NEW DATA ON *UTAHRAPTOR* RECOVERED DURING PREPARATION OF A MASS MORTALITY ASSEMBLAGE: DOES TAIL MORPHOLOGY DIFFERENTIATE DROMAEOSAURINES FROM VELOCIRAPTORINES?
- B133** **S.H. Burch, J.R. Hutchinson, X. Yao, X. Xu** ANALYSIS OF A THREE-DIMENSIONAL MUSCULOSKELETAL MODEL OF THE FORELIMB OF *GUANLONG WUCAI* (THEROPODA: TYRANNOSAUROIDEA)
- B134** **A. Torices, F. Ortega, A. Pérez-García** GONDWANAN THEROPOD DINOSAURS IN THE CENOMANIAN OF SOUTHWESTERN EUROPE
- B135** **A.E. Fernandes, O. Walter Mischa Rauhut** A NEW GNATHOSAURINE (PTEROSAURIA, ARCHAEOPTERODACTYLOIDEA) FROM THE KIMMERIDGIAN OF BRUNN, GERMANY
- B136** **P.E. dePolo, T.E. Williamson, S.L. Shelley, S.L. Brusatte** OCCURRENCES OF *PANTOLAMBDA INTERMEDIUM* IN THE SAN JUAN BASIN, NEW MEXICO, USA
- B137** **P. Rhinehart, K. Beard** A NEW SPECIES OF *ACMEODON* (MAMMALIA, CIMOLESTIDAE) FROM THE EARLY TIFFANIAN (LATE PALEOCENE) OF THE BISON BASIN, WYOMING, USA
- B138** **M.U. Tablizo, G.D. van den Bergh, A.S. Fernando** REVISITING THE *STEGODON* OF LUZON, PHILIPPINES – INSIGHTS FROM NEW FOSSIL MATERIAL
- B139** **N.S. Vitek, N. Rutig, E.R. Seiffert, S. Heritage, E. Aaron, I. Nengo, P. Princehouse** NEW HYRACOIDS (MAMMALIA: AFROTHERIA) FROM THE EARLY OLIGOCENE OF TOPERNAWI, TURKANA BASIN, KENYA

- B140** S.M. Cote, J. Casorso, G. Semprebon, S. Robson, A.A. Hall, J. Kingston, C. Butts PRELIMINARY RESULTS FROM A MULTIPROXY STUDY OF RUMINANT DIETARY ECOLOGY IN THE EARLY MIOCENE OF EASTERN AFRICA
- B141** C.P. Bruce, S. Wallace EXTREME DENTAL VARIATION WITHIN A SPATIALLY AND TEMPORALLY CONSTRAINED POPULATION OF FOSSIL BADGERS HIGHLIGHTS THE PITFALLS OF DESCRIBING NEW SPECIES BASED ON SMALL SAMPLES
- B142** V.L. Naples, M. Haji-Sheikh *SMILODON FATALIS*: THE PROWLING PREDATOR PURSUING PREY
- B144** J.J. Person, C. Boyd NEW MATERIAL OF THE ENIGMATIC MAMMAL *IDIOGENOMYS*: A LATE SURVIVING NORTH AMERICAN LINEAGE OF BASAL GLIRES?
- B145** T.E. Williamson, S.L. Shelley, G. Funston, J.R. Wible, S.L. Brusatte TRIANGULAR BEAST: NEW FOSSILS SHED LIGHT ON *DELTATHERIUM*, AN ENIGMATIC EARLY PALEOCENE MAMMAL FROM NEW MEXICO
- B146** Z. Li, T. Mörs, Y. Zhang, K. Xie, Y. Li PERISSODACTYLS FROM THE EARLY MIOCENE OF LANZHOU BASIN, NORTHWEST CHINA
- B147** T.W. Scaife, T.J. Gaudin CRANIAL OSTEOLOGY OF A JUVENILE SPECIMEN OF *ACRATOCNUS YE* (MAMMALIA, XENARTHRA, FOLIVORA) AND ITS ONTOGENETIC AND PHYLOGENETIC IMPLICATIONS
- B148** S.W. Irvine, S.G. Chester, L.T. Holbrook, E.J. Sargis MAMMALIAN DISTAL HUMERI FROM THE BUG CREEK ANTHILLS, MONTANA
- B149** E.V. Miller, L.K. Stroik, K. Townsend, J.W. Westgate, P.C. Murphey, A.R. Friscia, P. Higgins COMPARISON OF MIDDLE AND LATE UINTAN (MIDDLE EOCENE) FAUNAL COMMUNITY COMPOSITION IN THE UINTA BASIN, UTAH
- B150** J.M. Downey, G. Pizzini, B. Cho, T.R. Lyson, S.G. Chester, R. Rogers, C. Badgley, L.N. Weaver TAPHONOMY OF MOUNTAIN-PROXIMAL VERTEBRATE MICROFOSSIL BONEBEDS FROM THE EARLY PALEOCENE DENVER FORMATION OF THE DENVER BASIN (EL PASO COUNTY, COLORADO)
- B151** A.K. Behrensmeyer, J.H. Miller BONE WEATHERING UPDATE – RATES, ENVIRONMENTAL CONTROLS, AND APPLICATIONS TO THE FOSSIL RECORD
- B152** A.E. Kort BIZARRE BACKBONES: A SYNAPOMORPHY IN THE LUMBAR VERTEBRAE FOR FERUNGULATA
- B153** S. Hoffmann, E.C. Kirk, T. Rowe, R. Cifelli INNER EAR MORPHOLOGY OF AN EARLY CRETACEOUS EUTRICONODONTAN FROM THE CLOVERLY FORMATION (MONTANA, USA)
- B154** C.M. Janis, M. Jones, K. Travouillon LIMB PROPORTIONS IN HOPPING MAMMALS AND THE LOCOMOTION OF ARGYROLAGIDS
- B156** J. Benoit, C. Kammerer, R. Smith LIKE A TYRANNOSAUR IN THE PALEOCENE: DID A GORGONOPSID SURVIVE THE END-PERMIAN EXTINCTION?

FRIDAY MORNING, NOVEMBER 4, 2022
TECHNICAL SESSION 9: MAMMALS
MEETING ROOM METRO CENTRE
MODERATORS: David Fox and Kirsten Meltesen

- 8:00** A. Goswami, E. Noirault, E. Coombs, J. Clavel, A. Fabre, T. Halliday, M.M. Churchill, A. Curtis, A. Watanabe, N. Simmons, D.L. Fox, B. Beatty, J. Geisler, R.N. Felice ATTENUATED EVOLUTION OF MAMMALS THROUGH THE CENOZOIC
- 8:15** J.X. Samuels, J.A. Schap CHANGES IN THE STRUCTURE OF RODENT AND LAGOMORPH FAUNAS THROUGH THE CENOZOIC OF NORTH AMERICA WERE INFLUENCED BY REGIONAL TOPOGRAPHY AND CLIMATE
- 8:30** Z.T. Calamari, C.E. Finck, J. Julius, G. Droznik, P. Barden DID ABUNDANT ANTS LEAD TO ABUNDANT ANTEATERS? ASSESSING THE LINK BETWEEN ANT AND TERMITE ABUNDANCE AND THE DIVERSITY OF OBLIGATE MYRMECOPHAGES IN EXTINCT AND EXTANT XENARTHRA

- 8:45 R.K. MCAFEE, J. Almonte** UNIQUE ZYGOMATIC ARCH COMPLEXES IN THE LATE PLEISTOCENE-EARLY HOLOCENE GROUND SLOTH *NEOCNUS* FROM THE DOMINICAN REPUBLIC
- 9:00 R.W. Burroughs** INVESTIGATING THE ROLE OF DEVELOPMENTAL MODULARITY AS AN EVOLUTIONARY MECHANISM WITHIN RODENT MOLARS
- 9:15 F.R. O'Keefe, R. Dunn, E. Weitzel, M. Waters, W.J. Binder, J.R. Southon, J. Cohen, J.A. Meachen, L.R. DeSantis, E.L. Lindsey** CLIMATE CHANGE PRIMED SOUTHERN CALIFORNIA FOR HUMAN-IGNITED ECOSYSTEM COLLAPSE 13,200 YEARS AGO: A HIGH-RESOLUTION RADIOCARBON RECORD OF MEGAFaUNAL MASS EXTINCTION AT RANCHO LA BREA
- 9:30 A.P. Kaur** NEW FOSSIL MAMMALIAN ASSEMBLAGES AND FIRST RECORD OF OSTRICH FROM THE PINJORE FORMATION (2.58–0.63 MILLION YEARS) OF THE INDIAN SIWALIKS
- 9:45 A. Huynh** BRIDGING WILDLIFE CRIME WITH FOSSIL CRIME: THE CONNECTION BETWEEN MAMMOTHS AND BLOOD IVORY
- 10:15 H.Z. Fulghum, P. Polly** EVALUATING DIETARY DIVERSITY IN TRIBOSPHENIC DENTITIONS: MACHINE LEARNING ANALYSES OF SIMPLE LINEAR MEASUREMENTS DISTINGUISH PRIMARY AND SECONDARY DIET TYPES IN EXTANT TAXA
- 10:30 T.R. Pansani** HUMAN-MEGAFaUNA INTERACTION IN SOUTH AMERICA: DEEP INVESTIGATION OF CULTURAL ORNAMENTS MADE FROM GIANT SLOTH BONES IN CENTRAL BRAZIL, LATE PLEISTOCENE
- 10:45 K.M. Meltesen, T. So, G. Youzwshyn, G.P. Wilson Mantilla** INSIGHTS FROM AN UNDERSTUDIED MAMMAL SITE FROM THE MID-PALEOCENE (TORREJONIAN) OF SOUTHEASTERN MONTANA
- 11:00 J. Orcutt, N. Famoso** STATISTICAL ANALYSIS OF DENTAL VARIATION IN THE EOCENE-MIOCENE FELIFORM *PALAEOGALE*
- 11:15 C.J. Everett, T.A. Deméré, A. Wyss** NEW TAXA FROM THE LATE OLIGOCENE AND EARLY MIOCENE OF THE PACIFIC NORTHWEST ELUCIDATE TRENDS IN BASAL PAN-PINNIPED DENTAL EVOLUTION
- 11:30 M.I. Bari, T. Farhad, N. Nandi, S. Chakravorti** MEGAVERTEBRATE REMAINS FROM THE PLIO-PLEISTOCENE OF BANGLADESH – A NEW WINDOW INTO VERTEBRATE PALEONTOLOGY
- 11:45 D.L. Fox, W.E. Lukens** QUANTIFYING ESTIMATES OF C₄ FRACTIONS IN DIETS AND PALEOSOLS USING A COMPILATION OF PLANT $\delta^{13}\text{C}$ VALUES AND A MONTE CARLO MODEL TO PROPAGATE UNCERTAINTIES
- 12:00 E.A. Armstrong** NEW POSTCRANIAL MATERIAL OF *ANTIACODON PYGMAEUS* (MAMMALIA, ARTIODACTYLA) FROM THE MIDDLE EOCENE OF WYOMING, AND A PHYLOGENETIC ANALYSIS OF NORTH AMERICAN DICHOBUNOID ARTIODACTYLS

FRIDAY MORNING, NOVEMBER 4, 2022
TECHNICAL SESSION 10: SOFT TISSUES & TAPHONOMY
MEETING ROOM METRO EAST
MODERATORS: Holly Smith and Charles Woolley

- 8:00 R.T. Figueroa, M. Friedman** OUTSTANDING THREE-DIMENSIONAL PRESERVATION OF BRAINS AND CRANIAL NERVES IN LATE PALEOZOIC STEM ACTINOPTERYGIANS
- 8:15 M.Q. Gaetano, J.H. Miller, E. Wald, P. Druckenmiller** SINKING OUR TEETH IN: RECORDS OF CARNIVORAN MODIFICATION ON BONES OF SMALL PREY
- 8:30 H.E. Smith** A NOVEL HOLISTIC APPROACH TO TAPHONOMIC ANALYSES OF TROPICAL CAVE FOSSILS
- 8:45 M.C. Wood** PREDICTING PATTERNS OF VERTEBRATE FOSSIL PRESERVATION USING VARIATION IN RATES OF STRATIGRAPHIC ACCUMULATION: A CASE STUDY IN A MAMMAL-RICH INLAND BASIN (WASHAKIE FORMATION, WY)
- 9:00 J. Wiemann** TRACING THE FIDELITY OF MOLECULAR BIOSIGNATURES THROUGH GEOLOGICAL TIME TO REVEAL MAJOR STEPS IN THE EVOLUTION OF VERTEBRATES
- 9:15 D.G. Cerio, L.M. Witmer** CONSTRAINT AND ADAPTATION IN THE PARAVIAN VISUAL SYSTEM: MINIATURIZATION AND THE FUNCTIONAL ANATOMY OF THE NICITATING MEMBRANE APPARATUS

- 9:30** **J.L. O'Neill, S. Keenan** COMPARING THE ACCURACY AND PRECISION OF XRF AND ICP-MS ANALYSES OF FOSSIL BONE GEOCHEMISTRY
- 9:45** **M. Qvarnstrom, G. Pienkowski, K. Dollman, P. Tafforeau, G. Niedzwiedzki** SCRAMBLED EGGS: SYNCHROTRON SCANS OF EGGS FROM THE EARLIEST JURASSIC SEEM TO REVEAL UNUSUAL TRAITS IN EARLY DINOSAUR EMBRYOS
- 10:15** **C.A. Boyd, S.K. Drumheller, J.B. Scannella** A *THESCÉLOSAURUS* SPECIMEN WITH UNIQUE ANATOMICAL FEATURES PROVIDES ADDITIONAL EVIDENCE FOR THE DEFLATION AND DESICCATION MODEL OF DERMAL TISSUE FOSSILIZATION
- 10:30** **H.P. Tsai, C. Griffin** QUANTITATIVE RECONSTRUCTION OF CARTILAGINOUS COMPONENTS OF THE SAUROPOD HINDLIMB MODULE: EVOLUTIONARY TRANSITIONS AND FUNCTIONAL SIGNIFICANCE
- 10:45** **J.A. Whitlock, G. Fischer** DESCRIPTION OF A SKIN IMPRESSION OF A DIPLODOCID SAUROPOD FROM DINOSAUR NATIONAL MONUMENT (TITHONIAN), MORRISON FORMATION, USA
- 11:00** **W.L. Parsons, K.M. Parsons** EXCEPTIONALLY WELL-PRESERVED SOFT TISSUE REMAINS IN A THEROPOD EGG/EMBRYO FROM THE LOWER CRETACEOUS CLOVERLY FORMATION OF CENTRAL MONTANA
- 11:15** **T. Lyman** TAPHONOMY OF MARINE REPTILES AND DINOSAURS OF THE UPPER CRETACEOUS MORENO FORMATION, CALIFORNIA
- 11:30** **C.H. Woolley, D.J. Bottjer, F.A. Corsetti, N.D. Smith** METRICS OF SKELETAL RECORD COMPLETENESS REVEAL THE EXISTENCE OF A “PHYLOGENETIC LAGERSTÄTTEN” EFFECT IN THE UPPER CRETACEOUS AEOLIAN DEPOSITS OF THE GOBI DESERT
- 11:45** **Z.J. Hannebaum, D. Varricchio** A STUDY OF *ORODROMEUS* TAPHONOMY AT EGG MOUNTAIN, PART OF THE UPPER CRETACEOUS TWO MEDICINE FORMATION NEAR CHOTEAU, MONTANA.
- 12:00** **K.L. Tucker, D. Varricchio** A MYSTERIOUS CLUTCH OF ALTERED DINOSAUR EGGS FROM THE TWO MEDICINE FORMATION OF MONTANA

FRIDAY MORNING, NOVEMBER 4, 2022
TECHNICAL SESSION 11: SYNAPSIDA
MEETING ROOM METRO WEST
MODERATORS: Katrina Jones and Christian Kammerer

- 8:00** **A. Mann, A.C. Henrici, R.W. Hook, S.E. Pierce, H. Sues** UPPER CARBONIFEROUS “PELYCOSAUERS” OF LINTON, OHIO, REVISITED, AND NEW INSIGHTS INTO THE EARLY EVOLUTION OF HERBIVORY IN SYNAPSIDS
- 8:15** **K. Brink, A.J. Snyder** CUT AND TEAR: ORAL PROCESSING IN THE HETERODONT NON-MAMMALIAN SYNAPSID *DIMETRODON* THROUGH FINITE ELEMENT ANALYSIS
- 8:30** **A. Canoville** PRELIMINARY PALEOHISTOLOGICAL INVESTIGATION OF *DIMETRODON TEUTONIS* FROM THE BROMACKER LOCALITY OF GERMANY
- 8:45** **D. Grossnickle, S. Hellert, G. Lloyd, C. Kammerer, K.D. Angielczyk** SURVIVAL OF THE NOVEL: DERIVED FAUNIVORES ARE THE FORERUNNERS OF MAJOR SYNAPSID RADIATIONS
- 9:00** **S. Singh, A. Elsler, T. Stubbs, E. Rayfield, M.J. Benton** FUNCTIONAL MORPHOLOGY REVEALS THE FEEDING MODES OF CARNIVOROUS NON-MAMMALIAN SYNAPSIDS AND THE EVOLUTION OF TERRESTRIAL ECOLOGICAL DYNAMICS THROUGH THE LATE PALEOZOIC
- 9:15** **K. Jones, K.D. Angielczyk, S.E. Pierce** EVOLUTIONARY ORIGINS OF MAMMALIAN AXIAL FUNCTION REVEALED THROUGH DIGITAL BENDING EXPERIMENTS
- 9:30** **S. Jirah, B.S. Rubidge, F. Abdala** TAXONOMIC REVISION OF THE TITANOSUCHIDAE (THERAPSIDA, DINOCEPHALIA) OF THE KAROO BASIN, SOUTH AFRICA: A KEY TO UNDERSTANDING MIDDLE PERMIAN TETRAPOD DIVERSITY
- 9:45** **J.K. Lungmus, K.D. Angielczyk** INCONGRUENCE OF MORPHOLOGICAL DISPARITY AND EVOLUTIONARY RATE IN THE FORELIMBS OF PALEOZOIC SYNAPSIDS

- 10:15 P. Viglietti, A. Rojas, M. Rosvall, B. Klimes, K.D. Angielczyk** NETWORK-BASED BIOSTRATIGRAPHY FOR THE LATE PERMIAN-MID TRIASSIC BEAUFORT GROUP IN SOUTH AFRICA ENHANCES BIOZONE APPLICABILITY AND STRATIGRAPHIC CORRELATION
- 10:30 A. Huttenlocker, Z.T. Kulik, C. Sidor** NEW BAURIAMORPH RECORDS FROM THE EARLY TRIASSIC OF SOUTHERN PANGAEA TEST THE PRINCIPLE OF GEOGRAPHIC EXCLUSION IN THE GLOBAL RADIATION OF BAURIOIDS AND CYNODONT (SYNAPSIDA)
- 10:45 C. Sidor, B. Gee, W.R. Hammer, A. Huttenlocker, Z.T. Kulik, P. Makovicky, J. McIntosh, N.D. Smith, N.J. Tabor, M.R. Whitney** THE FOSSIL RECORD OF THE TRIASSIC FREMOUW FORMATION (ANTARCTICA): HISTORY OF COLLECTING AND A NEW BAURIAMORPH (THERAPSIDA: THEROCEPHALIA)
- 11:00 C. Kammerer, E. Butler, P. Viglietti, J. Botha** THE FIRST RECORD OF *INOSTRANCEVIA* IN AFRICA INDICATES RAPID TURNOVER OF TOP PREDATORS ON LAND DURING THE TERMINAL PERMIAN
- 11:15 C.P. Abbott, K.D. Angielczyk, M. Webster** ONTOGENETIC MECHANISMS OF BODY SIZE CHANGE IN THE FOSSIL RECORD: IMPLICATIONS FOR THE LILLIPUT EFFECT AND A CASE STUDY OF *LYSTROSAURUS* AND *MOSCHORHINUS* IN THE KAROO BASIN, SOUTH AFRICA
- 11:30 K.D. Angielczyk, J. Liu, C. Sidor, W. Yang** STRATIGRAPHIC AND GEOGRAPHIC OCCURRENCES OF PERMO-TRIASSIC TETRAPODS IN THE BOGDA MOUNTAINS, NW CHINA: IMPLICATIONS OF A NEW CYCLOSTRATIGRAPHIC FRAMEWORK AND BAYESIAN AGE MODEL
- 11:45 H. George, C. Kammerer, D. Foffa, S.L. Brusatte** NEW DATA ON THE ENDOCRANIAL ANATOMY OF THE LATE PERMIAN SCOTTISH DICYNODONT *GORDONIA* BASED ON COMPUTED TOMOGRAPHY
- 12:00 Z.T. Kulik, C. Sidor** ASSESSING AGE STRUCTURE IN A MULTITAXIC CYNODONT ASSEMBLAGE FROM THE MIDDLE TRIASSIC MANDA BEDS OF TANZANIA

FRIDAY AFTERNOON, NOVEMBER 4, 2022
TECHNICAL SESSION 12: RODENTS & QUATERNARY MAMMALS
MEETING ROOM METRO CENTRE
MODERATORS: Advait Jukar and Melissa Macias

- 1:45 I.A. Kerr, A.B. Camens, T.H. Worthy, J.D. van Zoelen, G.J. Prideaux** ECOLOGY AND EVOLUTION OF GIANT KANGAROOS OF THE PLIO-PLEISTOCENE GENUS *PROTEMNODON*
- 2:00 A.M. Jukar, G. Bhat, S. Parfitt, N. Ashton, M. Dickinson, A.M. Dar, M.S. Lone, B. Thusu, J. Craig** A NEW CRANIUM OF *PALAEOLOXODON TURKMENICUS* (PROBOSCIDEA, ELEPHANTIDAE) FROM KASHMIR, AND THE DIVERSITY OF PROBOSCIDEANS FROM THE INDIAN SUBCONTINENT
- 2:15 B.R. Peacock, E. Karpinski, C. Widga, A. Boehm, M. Kuch, T.J. Murchie, M.E. Thompson, H.N. Poinar** MOLECULAR AND MORPHOLOGICAL ASSESSMENTS OF MASTODONS OF THE AMERICAN FALLS RESERVOIR, IDAHO: AMERICAN? PACIFIC? BOTH?
- 2:30 L.W. Vinola, J.I. Bloch, J.N. Almonte, M.J. LeFebvre** THE BIOGEOGRAPHY AND EXTINCTION TIMING OF ENDEMIC RODENTS ON HISPANIOLA DURING THE HOLOCENE
- 2:45 A.W. Haveles, K. Fox-Dobbs, D.L. Fox** TREATING THE PRESENT AS THE PAST: ITERATIVE MODELING OF MODERN GRASSLAND RODENT DIETS FROM STABLE ISOTOPE ANALYSES TO CONSTRAIN INTERPRETATIONS OF ISOTOPIC DATA FROM FOSSILS
- 3:00 S. López-Torres, O.C. Bertrand, M.M. Lang, M.T. Silcox, J. Meng** VIRTUAL ENDOCAST OF THE LATE EOCENE *ANAGALE GOBIENSIS* (ANAGALIDAE) OF NEI MONGOL, CHINA: FRESH INSIGHTS ON THE BRAIN EVOLUTION OF EUARCHONTOGLIRES
- 3:15 D.C. Kalthoff, O. Fejfar, Y. Kimura, B. Bailey, T. Mörs** PHYLOGENETIC RELATIONSHIPS OF EOMYIDAE TO OTHER CLADES WITHIN GEOMORPHA: NEW RESULTS FROM INCISOR ENAMEL MICROSTRUCTURE ANALYSIS
- 3:30 M.K. Macias, E.B. Kitao** A NICE DATE AT THE BEACH: RADIOCARBON ANALYSIS OF A RANCHOLABREAN MARINE TERRACE LOCALITY AT VANDENBERG AIR FORCE BASE, SANTA BARBARA COUNTY, CALIFORNIA

- 3:45 **E.L. Lindsey, K.L. Seymour, J.R. Southon** NEW RADIOCARBON DATES ON MEGAFUNAL DUNG, INSECTS AND WOOD SHED LIGHT ON CHRONOLOGY OF NEOTROPICAL ASPHALTIC DEPOSITS
- 4:00 **J.H. Miller, C. Simpson** MAMMOTH EXTINCTION HIGHLIGHTS CONTRIBUTIONS TO eDNA RECORDS BY THE DEAD AND DECAYING

FRIDAY AFTERNOON, NOVEMBER 4, 2022
TECHNICAL SESSION 13: EARLY ARCHOSAURS & PTEROSAURS
MEETING ROOM METRO EAST
MODERATORS: Robin Whatley and Davide Foffa

- 1:45 **L. Czepinski, M. Talanda, A. Rytel, W. Pawlak, T. Szczygielski, T. Sulej** A MIDDLE TRIASSIC BONEBED WITH AQUATIC AND TERRESTRIAL VERTEBRATES IN MIEDARY, POLAND
- 2:00 **P. Byrne, L. Legendre, S. Echols, C. Farmer, J.D. Gardner, Y. Wu, A. Huttenlocker** ELEVATED AEROBIC CAPACITY IN TRIASSIC ARCHOSAURS SUPPORTED BY MODELED REDUCTIONS IN RED BLOOD CELL SIZES
- 2:15 **O.E. Demuth, A.L. Wiseman, J.R. Hutchinson** SUSTAINABLE BIPEDAL LOCOMOTION IN *EUPARKERIA*? QUANTITATIVE BIOMECHANICAL ASSESSMENT OF ITS LOCOMOTORY CAPABILITIES
- 2:30 **S. Spiekman, M. Ezcurra, R.J. Butler, N.C. Fraser, S. Maidment** NEW INSIGHTS INTO THE ARCHOSAUR FAUNA (NEOTHEROPODA; PSEUDOSUCHIA; CROCODYLOMORPHA) FROM THE LATE TRIASSIC FISSURE FILLS LOCALITY OF PANT-Y-FFYNNON WALES (UK)
- 2:45 **R.L. Whatley, J. Flynn, L. Ranivoharimanana, A.R. Wyss** SYMPATRIC SPECIES OF *ISALORHYNCHUS* (RHYNCHOSAURIA, ARCHOSAURIFORMES) AND THE FIRST OCCURRENCE OF *HYPERODAPEDON* FROM THE TRIASSIC OF MADAGASCAR
- 3:00 **D. Foffa, E.M. Dunne, A. Farnsworth, B.M. Wynd, R.J. Butler, S.J. Nesbitt, N.C. Fraser, S.L. Brusatte, D.J. Lunt, P. Valdes, S. Walsh, P.M. Barrett** CLIMATE DRIVERS OF EARLY PTEROSAURIFORM EVOLUTION
- 3:15 **I. Welch, M.B. Habib** FROM SEA TO SKY: WATER LAUNCH AND SOARING PERFORMANCE IN THE LATE CRETACEOUS PTEROSAUR, *NYCTOSAURUS*
- 3:30 **N. Jagielska, S.L. Brusatte, M. O'Sullivan, I. Butler, T. Challands, N. Clark, N.C. Fraser, A. Penny, D. Ross, M. Wilkinson, G. Funston** THE REPTILIAN AVIATION PIONEERS: NEW MIDDLE JURASSIC FOSSILS UNCOVER THE UNSEEN DIVERSITY OF NON-PTERODACTYLOID PTEROSAURS
- 3:45 **A.J. Fitch, B.S. Bhullar, A.C. Pritchard, J. Bevitt, D. Lovelace, S.J. Nesbitt** ORIGINS OF PTEROSAURIA: HIDDEN FOSSIL RECORD AND NEAR EXTINCTIONS OF THE FIRST AND LONGEST-LASTING FLYING VERTEBRATE LINEAGE REVEALED THROUGH A NEW PHYLOGENETIC HYPOTHESIS
- 4:00 **H.N. Thomas, D.W. Hone, J. Peterson** THE FEATHERED SERPENT DID NOT LIVE IN HELL: REAPPRAISAL OF AN AZHDARCHID CERVICAL VERTEBRA FROM THE HELL CREEK FORMATION OF MONTANA

FRIDAY AFTERNOON, NOVEMBER 4, 2022
TECHNICAL SESSION 14: SQUAMATES & TURTLES
MEETING ROOM METRO WEST
MODERATORS: Mark Powers and Holger Petermann

- 1:45 **R.E. Armfield, J. Gauthier** WHAT DOES IT MEAN TO BE A GAPE-LIMITED SNAKE, AND CAN WE IDENTIFY ONE IN THE FOSSIL RECORD?
- 2:00 **S.A. Martinez** DETERMINING THE AFFINITY OF FOSSIL XANTUSIID JAWS WITH IMPLICATIONS FOR POST K-PG SQUAMATE DIVERSITY
- 2:15 **H. Petermann, T.R. Lyson** A HIGHLY-DIVERSE SQUAMATE FAUNA FROM THE LATE MAASTRICHTIAN OF THE DENVER FORMATION (COLORADO, USA) HIGHLIGHTS HEALTHY ECOSYSTEMS PERSISTED RIGHT UNTIL THE END CRETACEOUS MASS EXTINCTION
- 2:30 **M.J. Powers, H. Berryere, C.R. Strong, A. Palci, A. LeBlanc, M. Doschak, M.W. Caldwell** TOOTH REPLACEMENT IN SNAKES: SYNAPOMORPHY OR CHAOS?

- 2:45** **D. Meyer, C.D. Brownstein, J. Gauthier** ANALYSIS OF A STEM-GEKKOTAN FROM THE MORRISON FORMATION PLACES THE SOLNHOFEN SQUAMATES ON THE TREE OF LIFE
- 3:00** **J.J. Head, R. Benson, S. Evans** RUNNING WITH THE DEVILS: POSTCRANIAL OSTEOLOGY OF THE ENIGMATIC JURASSIC PARVIRAPTORID SQUAMATES, AND THEIR IMPLICATIONS FOR THE EVOLUTION OF THE SNAKE BODY FORM.
- 3:15** **J.X. Samuels, J.A. Conley** COMMUNITY STRUCTURE ANALYSIS OF TURTLES WITH APPLICATION TO THE EARLY PLOIOCENE GRAY FOSSIL SITE OF NORTHEASTERN TENNESSEE
- 3:30** **H.F. Smith, B. Adrian, A.T. McDonald, D.G. Wolfe** NEW TURTLE DISCOVERIES FROM THE MENEFEE FORMATION (CAMPANIAN), NEW MEXICO, U.S.A.
- 3:45** **B. Shipps, K.D. Angielczyk, B.R. Peacock** NO TEETH, NO PROBLEM: ORIENTATION PATCH COUNT PREDICTS DIET IN TURTLES
- 4:00** **S. Tada, T. Tsuihiji, D.J. Morgan, L.M. Witmer** CEPHALIC VASCULATURE OF EXTANT TURTLES: THEIR THERMAL PHYSIOLOGY AND ITS EVOLUTIONARY IMPLICATIONS

FRIDAY AFTERNOON, NOVEMBER 4, 2022

REGULAR POSTER SESSION 3

MEETING ROOM FRONTENAC

Authors must be present from 4:30 – 6:30 p.m. on Friday, November 4

- B157** **C. Fielitz, K. Super** *URENCHELYS ABDITUS* WILEY AND STEWART 1981 (TELEOSTEI: ANGUILLIFORMES) FROM THE SMOKY HILL CHALK MEMBER OF THE NIOBRARA FORMATION (UPPER CRETACEOUS: SANTONIAN) OF KANSAS, USA IS NOT A MEMBER OF *URENCHELYS*
- B158** **A.B. Heckert, C.J. Duffin, P.J. Hancox** DIMINUTIVE HYBODONT CHONDRICHTHYANS FROM THE LOWER TRIASSIC OF SOUTH AFRICA AND IMPLICATIONS FOR RECOVERY OF NONMARINE ECOSYSTEMS DURING THE EARLY TRIASSIC
- B159** **J. Li, Z. Sun, C. Gilles, D. Jiang** A DIVERSE SHARK FAUNA FROM THE SMITHIAN-SPATHIAN INTERVAL AT ZUODENG SECTION, GUNAGXI PROVINCE, SOUTH CHINA
- B160** **K.J. Kean, C. Perez-Ben, M. Danto, N. Froebish** PATTERNS AND PROCESSES OF SIMPLIFICATION IN THE TEMPORAL SERIES OF STEM TETRAPODS
- B161** **A. Fabrício Machado, F. Lima Pinheiro, V. Dutra Paes-Neto, T. Rodrigues Simões, S.E. Pierce** UNDERSTANDING THE PERMO-TRIASSIC MASS EXTINCTION THROUGH TETRAPOD FOSSILS FROM SOUTHERN BRAZIL
- B162** **E.A. Panigot, H. Petermann, B.S. Rubidge, G.S. Bever, T.R. Lyson** AN ASSEMBLAGE OF DIAPSID REPTILES FROM THE MIDDLE PERMIAN OF SOUTH AFRICA AND THE EARLY HISTORY OF PAN-LEPIDOSAURIA
- B163** **M.E. Elliott, X.A. Jenkins, P. Viglietti, B.R. Peacock** RHYNCHOSAURS (STENAUORHYNCHINAE) FROM THE RED MARL FORMATION, LUANGWA BASIN (ZAMBIA) REINFORCE CORRELATION WITH THE RUHUU BASIN (TANZANIA) AND MIDDLE-LATE TRIASSIC ASSEMBLAGES OF SOUTH AMERICA
- B164** **A. LeBlanc, A. Morrell, S. Sirovica, M. Al-Jawad, D. Labonte, O. Addison** AT THE CUTTING EDGE: STRUCTURAL AND ELEMENTAL COMPLEXITY OF ZIPHODONT TOOTH ENAMEL IN EXTANT AND FOSSIL REPTILES
- B165** **D. Rowe, R. Reisz, J. Bevirt** SKELETAL ANATOMY OF THE EARLY PERMIAN PARAREPTILE *DELORHYNCHUS CIFELLII* WITH NEW INFORMATION PROVIDED BY NEUTRON TOMOGRAPHY
- B166** **J.R. Milligan, E.L. Bamforth, K.T. Lindblad** A NEW PARTIAL SKELETON OF *CHAMPSOSAURUS* CF. *LARAMIENSIS* FROM THE PALEOCENE RAVENSCRAG FORMATION OF SOUTHWESTERN SASKATCHEWAN, CANADA: IMPLICATIONS FOR POST-K-PG EXTINCTION FAUNAL RECOVERY AND PALEOECOLOGY

- B167** J. Zonneveld, Z.E. Zonneveld, W.S. Bartels, M.K. Gingras, J.J. Head BARNACLE ATTACHMENT SCARS ON THE BONES OF LOGGERHEAD SEA TURTLES (*CARETTA CARETTA*), CUMBERLAND ISLAND, GEORGIA: IMPLICATIONS FOR THE PALEOECOLOGICAL, AND TAPHONOMIC ANALYSES OF FOSSIL SEA TURTLES
- B168** E.L. Bamforth, R.C. McKellar THE FIRST *PROGNATHODON* SP. (SQUAMATA, MOSASAURIDAE) FROM THE BEARPAW FORMATION OF SASKATCHEWAN, CANADA, AND IMPLICATIONS FOR MARINE PALEOECOLOGY IN THE BEARPAW SEA
- B169** J.J. Jacisin, A.M. Lawing GEOMETRIC MORPHOMETRICS OF SNAKE TRUNK VERTEBRAE INDICATE ECOMORPHOLOGICAL TRENDS, PHYLOGENETIC SIGNAL, AND CONVERGENCE ACROSS TAXONOMIC GROUPS
- B170** K. Ito, T. Kinugasa, K. Chiba, Y. Okuda, R. Takasaki, S. Hida, K. Yoshida, R. Hayashi, K. Osuka INTERLOCKING MECHANISMS OF CROCODYLIAN HINDLIMB JOINTS USING A PASSIVE MUSCULOTENDINOUS STRUCTURE DURING THE HIGH WALK
- B171** I. Pugh, A.B. Heckert, S.J. Nesbitt, M. Stocker, B. Lauer THREE-DIMENSIONAL PRESERVATION AND VARIATION OF DREPANOSAURS (REPTILIA:ARCHOSAURIFORMES) FROM THE UPPER TRIASSIC HOMESTEAD SITE (TRIASSIC:REVUELTIAN:MID-NORIAN) OF EAST-CENTRAL NEW MEXICO, U.S.A.
- B172** R. Adolf, D. D'Amore, A. Adolf, J.B. McHugh, S.K. Drumheller A HIGH FREQUENCY OF FOSSIL TOOTH MARKS FROM THE CEDAR MOUNTAIN FORMATION OF UTAH
- B173** N.C. Platt, C.A. Brochu, C. Parrelly, D.R. Leaphart A NEW NEOSUCHIAN CROCODYLIFORM FROM THE LOWER CRETACEOUS (ALBIAN-APTIAN) HOLLY CREEK FORMATION OF SOUTHWEST ARKANSAS AND ITS IMPLICATIONS ON THE RELATIONSHIPS OF NEOSUCHIA
- B174** C.M. Stefanic, K.M. Melstrom, N.D. Smith, L.M. Chiappe, A. Turner POSTCRANIAL ANATOMY OF *FRUITACHAMPSA CALLISONI* FROM THE UPPER JURASSIC MORRISON FORMATION OF WESTERN COLORADO
- B175** H. Allen, G.B. Lafaye, D.D. Johnson IT'S THE LITTLE THINGS IN LIFE: USING MICROFOSSILS TO EXPAND THE KNOWN VERTEBRATE CENSUS OF THE CRETACEOUS BLACKLEAF FORMATION IN SOUTHWEST MONTANA
- B177** K. Garland, A. Evans REVEALING THE EVOLUTION AND DEVELOPMENT OF LIVING AND EXTINCT THEROPOD BEAKS THROUGH A UNIVERSAL MODEL OF GROWTH
- B178** M. Reid, R. Benson THE EVOLUTION AND PHYLOGENY OF EARLY TELLURAVES ("LANDBIRDS")
- B179** T. Oswald, B. Curtice, M. Bolander, C. Lopez OBSERVATION OF CLAW USE OF THE RED-LEGGED SERIEMA (*CARIAMA CRISTATA*) AND ITS IMPLICATION FOR THE FUNCTION OF DEINONYCHOSAUR "KILLING CLAWS"
- B181** L. King, M. Kirchner-Smith A NEW CATHARTID FROM RANCHO LA BREA AND ITS IMPLICATIONS FOR VULTURE BIODIVERSITY
- B182** R.A. Bantim, A.F. Araujo, A.W. Kellner, J.M. Sayão, A.Á. Saraiva, B. Holgado A NEW SPECIMEN OF *TAPEJARA* FROM THE LOWER CRETACEOUS OF THE ROMUALDO FORMATION (ARARIPE BASIN, BRAZIL) REVEALS KEY INFORMATION ON MORPHOLOGICAL VARIATION IN CRANIAL CRESTS OF TAPEJARINE PTEROSAURS
- B183** O.S. Devereaux, M.C. Herne, N. Campione, J. Bevitt, P. Bell ORNITHOPOD CRANIODENTAL REMAINS FROM THE CENOMANIAN GRIMAN CREEK FORMATION, NEW SOUTH WALES, AUSTRALIA
- B184** M. Messai, M. Bazzi, Y. Haridy, D. Jomaa-Salmouna, B. Kear, F. Dhahri NEW RECORD OF NON-AVIAN DINOSAURS FROM THE GAFSA BASIN, WESTERN-CENTRAL TUNISIA
- B185** S. Sachs, A.H. Schwermann, J.J. Hornung, D. Madzia A NEW EARLY CRETACEOUS ASSEMBLAGE OF IGUANODONTIAN DINOSAURS FROM WESTERN GERMANY
- B186** T. Okoshi, H. Saito, F. Kubo, A. Takahashi, M. Saneyoshi, K. Chiba, M. Buuvei, K. Tsogtobaatar A NEW VERTEBRATE MICROFOSSIL ASSEMBLAGE FROM THE UPPER CRETACEOUS BAYNSHIRE FORMATION, GOBI DESERT, MONGOLIA

- B187** N.E. Morley, M.N. Hudgins, T. Wyenberg-Henzler, C. Sullivan A DESCRIPTIVE AND MORPHOMETRIC SURVEY OF NON-HADROSAURID ORNITHISCHIAN DINOSAUR DENTITIONS FROM THE DINOSAUR PARK FORMATION OF ALBERTA, CANADA
- B188** C. Caputo, K. Snyder, A. Chadwick, R. Ash, P. Ullmann USING TRACE ELEMENTS TO CHARACTERIZE THE GEOCHEMICAL HISTORY OF THE HANSON RANCH BONEBED, CRETACEOUS LANCE FORMATION, WYOMING
- B189** T. Joubarne, F. Therrien, D.K. Zelenitsky TAPHONOMIC COMPARISON OF TWO MONODOMINANT BONEBEDS OF *HYPACROSAURUS STEBINGERI* (HADROSAURIDAE: LAMBEOSAURINAE) FROM SOUTHERN ALBERTA AND MONTANA SHEDS LIGHT ON THE LIFE HISTORY OF HADROSAURUS
- B190** J.E. Diepenbrock A UNIQUE MORRISON FORMATION SITE FROM SOUTHERN WYOMING AND ITS FAUNAL IMPLICATIONS
- B191** A. Reutter Wagner, O. Walter Mischa Rauhut NEW SAUROPODOMORPH MATERIAL FROM THE EARLY TO MIDDLE JURASSIC OF MOROCCO AND INSIGHTS ON PREVIOUSLY DESCRIBED CERVICAL VERTEBRAE FROM THE HAUTE MOULOUYA BASIN
- B192** E.D. Johnson-Ransom, E. Snively, F. Li, X. Xu, A.J. Midzuk, U. Thon BROAD COMPARATIVE ANALYSIS OF TYRANNOSAUROID CRANIAL STRESSES AND BITE PERFORMANCE THROUGH MUSCLE FORCE RECONSTRUCTION AND FINITE ELEMENT ANALYSIS
- B193** C.W. Garros, M.J. Powers, A.D. Dyer, P. Currie SURVEY OF METATARSAL PALEOPATHOLOGIES IN COELUROSAURIA FROM THE DINOSAUR PARK FORMATION
- B194** H. Inaba, K. Chiba, M. Saneyoshi, T. Miyaji, A. Kawakami, Y. Takechi, K. Brink, H. Tsujigiwa DIFFERENT PROTEIN RECOVERY RATE IN FOSSIL BONE AND DENTINE SAMPLES: IMPLICATIONS FOR THE APPLICATION OF PALEOPROTEOMIC METHODS IN PALEONTOLOGICAL STUDIES
- B195** R. Ahmad, A. Khan, M. Waseem, M. Ameen IMPACT OF THE MIOCENE TO PLEISTOCENE ENVIRONMENTAL CHANGES ON THE ARTIODACTYL FAMILIES OF THE SIWALIK SUBGROUP OF PAKISTAN: ENAMEL HYPOPLASIA BASED STUDY
- B196** J.S. Silviria, C.I. Barrón-Ortiz SPECIMEN-LEVEL CLADISTIC ANALYSES OF GEOMETRIC MORPHOMETRIC CONFIGURATIONS: AN EXPERIMENT USING NEOGENE-QUATERNARY EQUID PREMOLARS
- B197** A. Pérez-Ramos, D. Lovelace, A. Hotchner, B. Figueirido THE BRAIN ARCHITECTURE OF *MIRACINONYX TRUMANI*
- B198** J.A. Pérez-Claros, B. Figueirido MORPHOLOGICAL VARIABILITY OF THE DENTITION OF THE ORDER CARNIVORA: THE UPPER TEETH UNDERGO MORE TRANSFORMATIONS THAN THE LOWER TEETH
- B199** L. Koper INITIAL COMPARISON OF THE AUDITORY MORPHOLOGY IN MODERN AND FOSSIL PINNIPEDS
- B200** N. Brand, J. Miller-Camp, M.D. Uhen WHERE IN THE WORLD DOES THAT WHALE HAIL FROM? PALEOBIOGEOGRAPHY AND DISPERSAL HISTORY OF STEM MYSTICETES
- B201** R.J. Strauch, J.A. Case MIDDLE MIOCENE CETACEAN FOSSILS FROM SHARKTOOTH HILL
- B202** S.F. Al-Ashqar, E.R. Seiffert, M.R. Borths, S. El-Sayed, M.S. Antar, H.M. Sallam A NEW LATE EOCENE HYSTRICOGNATHOUS RODENT (PHIOMORPHA) FROM THE JEBEL QATRANI FORMATION, FAYUM DEPRESSION OF EGYPT
- B203** Z. Xu, J.X. Samuels LATE NEOGENE CRICETID RODENT REMAINS FROM THE GRAY FOSSIL SITE OF EASTERN TENNESSE
- B204** S. Wright MAMMALS OF THE TURING PIT LOCALITY, MONONA COUNTY, IA: IMPLICATIONS FOR AGE AND PALEOENVIRONMENT
- B205** M. Babar, M. Nawaz, S.G. Abbas, M.A. Khan PROBOSCIDEANS REMAINS THE FROM CHINJI FORMATION (MIDDLE MIOCENE) OUTCROPS OF CHABBAR SYEDAN, PUNJAB, PAKISTAN

- B206** A. Sania, M. Ameen, S.G. Abbas, R. Hussain, M. Saqlain TOOTH FOSSIL REMAINS OF LATE MIOCENE (11.63–5.33 MA) LAND MAMMALS FROM NORTHERN PUNJAB, PAKISTAN
- B207** J. Rawson, P.G. Gill, A. Martinelli, M. Soares, C. Schultz, E. Rayfield THREE-DIMENSIONAL ANATOMY OF DERIVED SOUTH AMERICAN CYNODONTS AND HOMOPLASY IN THE EVOLUTION OF THE MAMMALIAN JAW JOINT
- B208** A. Huttenlocker, B.J. Small, B. Mueller, K. Dean, S. Chatterjee A NEW LATE TRIASSIC (NORIAN) DICYNODONT FROM THE TECOVAS FORMATION (DOCKUM GROUP) OF TEXAS, U.S.A. REVEALS HIDDEN DICYNODONT DIVERSITY AND ABUNDANCE IN LAURASIA
- B209** M.D. Heck, S. Mohler, C. Sickles, J. Noviello, D. Hoffman, L. Thrasher, J. Borst, B.F. Mohler LOCATING SUBSURFACE FOSSILS USING STATISTICAL ANALYSIS OF GAMMA DETECTION
- B210** D.R. Pittinger, E. Simpson, M. Wizevich, G. Rogers, K. Lazer PRESERVED VERTEBRATE TRACKS IN PUSTULAR MICROBIAL MATS, LAKE POWELL SHORELINE: A MODERN ANALOG FOR THE MILL CANYON DINOSAUR TRACKSITE OF MOAB, UTAH
- B266** N. Campione, K. Allison, M. Dempsey, K. Bates DEVELOPING A SCALING METHOD TO ESTIMATE THE CENTER OF MASS IN DINOSAURS

SATURDAY MORNING, NOVEMBER 5, 2022

TECHNICAL SESSION 15: THEROPODS

MEETING ROOM METRO CENTRE

MODERATORS: Justyna Slowiak-Morkovina and Matteo Fabbri

- 8:00** A.A. Ruebenstahl, J.G. Napoli, B.S. Bhullar, D. Meyer A REASSESSMENT OF *COELURUS FRAGILIS*
- 8:15** P. Makovicky, J. Canale, S. Apesteguía, P. Gallina, J. Mitchell, N.D. Smith, T. Cullen, A. Shinya, A. Haluza, F. Gianechini A NEW CARCHARODONTOSAURID FROM THE NEUQUÉN GROUP, PATAGONIA, ARGENTINA, WITH A NEAR COMPLETE SKULL AND FORELIMBS INFORMS EVOLUTIONARY TRENDS IN THEROPOD ARM REDUCTION
- 8:30** T. Carr, J.G. Napoli, S.L. Brusatte, T.R. Holtz, D.W. Hone, T.E. Williamson, L.E. Zanno INSUFFICIENT EVIDENCE FOR MULTIPLE SPECIES OF *TYRANNOSAURUS* IN THE LATEST CRETACEOUS OF NORTH AMERICA: A COMMENT ON “THE TYRANT LIZARD KING, QUEEN AND EMPEROR: MULTIPLE LINES OF MORPHOLOGICAL AND STRATIGRAPHIC EVIDENCE SUPPORT SUBTLE EVOLUTION AND PROBABLE SPECIATION WITHIN THE NORTH AMERICAN GENUS *TYRANNOSAURUS*”
- 8:45** J. Hedge, L.E. Zanno QUANTITATIVE TESTING OF EGG SHELL ORNAMENTATION CATEGORIES WITHIN A CLUTCH OF DINOSAUR EGGS (ELONGATOLITHIDAE) FROM THE CEDAR MOUNTAIN FORMATION (CENOMANIAN) OF UTAH
- 9:00** B.J. Hart-Farrar, H. Woodward, L.E. Zanno, E. Snively 3D HISTOLOGY ON THE GROWTH, REMODELING, AND BIOMECHANICAL LOCOMOTOR LOADING IN JUVENILE TYRANNOSAURS COMPARED TO MODERN RATITES
- 9:15** R.D. Wilkinson, G. Funston, D.C. Evans A NEW SPECIES OF CAENAGNATHIDAE (THEROPODA: DINOSAURIA) FROM THE OLDMAN FORMATION (CAMPANIAN: LATE CRETACEOUS) OF ALBERTA, CANADA
- 9:30** R.E. Nottrodt, A. Dutchak, J.M. Theodor NEW BODY RATIOS PROVIDE ADDITIONAL SUPPORT FOR *DROMICEIOMIMUS* AS A VALID ORNITHOMIMID TAXON
- 9:45** D. Simon, D.C. Evans HISTOLOGICAL ANALYSIS OF *ANZU WYLIEI* (DINOSAURIA, OVIAPTOROSAURIA) REVEALS VARIATION IN ADULT BODY SIZE THROUGH TIME
- 10:15** D.K. Smith, D. Gillette HARD AND SOFT TISSUE RESTORATION IN THE THERIZINOSAUR *NOTHRONYCHUS GRAFFAMI* AS IT RELATES TO A STATIC POSTURE
- 10:30** R.S. Sombathy, M.D. D'Emic THE SIGNIFICANCE OF ‘MULTI-LAGS’ IN CORTICAL BONE INFERRED FROM A LARGE HISTOLOGICAL SAMPLE OF THE THEROPOD DINOSAUR *ALLOSAURUS*
- 10:45** J.C. Mallon, D.W. Hone HOW BIG COULD *T. REX* GET? A CASE STUDY FOR THE ESTIMATION OF MAXIMUM BODY SIZE IN EXTINCT ANIMALS

- 11:00** **J. Slowiak-Morkovina, T. Szczygielski, D. Surmik, B.M. Rothschild** BITEMARKS ON THE HEADS, TRAUMAS OF THE LEGS: PALEOPATHOLOGY IN *TARBOSAURUS BATAAR* (DINOSAURIA, TYRANNOSAURIDAE) FROM THE UPPER CRETACEOUS OF MONGOLIA
- 11:15** **T.M. Warnock-Juteau, S.M. Smith, T. Cullen** ELLIPTIC FOURIER ANALYSIS AS A TOOL FOR TAXONOMIC IDENTIFICATION OF ISOLATED THEROPOD PEDAL PHALANGES
- 11:30** **D. Palombi** THE CONSTRAINTS OF GIGANTISM IN THE FUNCTIONAL MORPHOLOGY OF THE CARCHARODONTOSAURID THEROPOD DINOSAURS METATARSUS
- 11:45** **M. Fabbri, S.M. Nebreda, J. Wiemann, A.A. Ruebenstahl, J.G. Napoli, M. Leibstein, M. Auditore, M. Norell, B.S. Bhullar, J.K. O'Connor** A NEW TROODONTID AND POSTCRANIAL EVOLUTION AMONG PARAVIANS
- 12:00** **Y. Wu** TOOTH REPLACEMENT AND RESORPTION PATTERNS OF A JAW WITH TROODONTID CHARACTERS FROM MONGOLIA PROVIDE INSIGHT INTO EVOLUTION OF THE THEROPOD TOOTH REPLACEMENT PROCESS

SATURDAY MORNING, NOVEMBER 5, 2022
TECHNICAL SESSION 16: HOOFED MAMMALS
MEETING ROOM METRO EAST
MODERATORS: Selina Robson and Hans Puschel

- 8:00** **S. Robson, S.T. Tucker, J.M. Theodor** THE SUBARCUATE FOSSA MORPHOLOGY OF SOME EXTINCT CAMELINES
- 8:15** **A.M. Balcarcel, M. Orliac, S. Lynch, M. Sánchez-Villagra** NEW SKULLS AND CRANIAL ENDOCASTS OF FOSSIL CAMELIDS SUGGEST GREAT BRAIN COMPLEXITY DURING THE PLEISTOCENE
- 8:30** **R. Hummel, D. Pagnac** MODELING NORTH AMERICAN MIOCENE HABITAT TURNOVER WITH MULTIVARIATE UNGULATE ECOMETRICS
- 8:45** **C.E. Finck, Z.T. Calamari** TOTAL EVIDENCE PHYLOGENETIC REASSESSMENT OF THE ENIGMATIC *MACHAEROMERYX TRAGULUS* (ARTIODACTYLA, RUMINANTIA) FROM UPPER HARRISON (LOWER MIOCENE) OF NEBRASKA
- 9:00** **J. Cohen, J. Frederickson, L.R. DeSantis, M.A. Engel, E.L. Lindsey, J.A. Meachen, F.R. O'Keefe, E. Scott, J.R. Southon, W.J. Binder** ASSESSING MIGRATION IN PLEISTOCENE HERBIVORES AT RANCHO LA BREA
- 9:15** **H.P. Puschel, S.L. Shelley, T.E. Williamson, F. Perini, J.R. Wible, S.L. Brusatte** NEW PHYLOGENY OF LITOPTERNA AND "ARCHAIC" PALEOGENE UNGULATES ENLIGHTENS THE INTERFAMILIARY AFFINITIES WITHIN THE ORDER
- 9:30** **H. Orłowski, D. Birlenbach, D.L. Fox** EVOLUTIONARY RATE ANALYSIS OF DENTITION REVEALS COMPLEX ASSEMBLY OF EQUID MOLAR APPARATUS
- 9:45** **E. Scott, K.E. Reed** *EURYGNATHOHIPPUS* FROM LEDI-GERARU, AFAR DEPRESSION, ETHIOPIA
- 10:15** **J.L. Cantalapiedra, O. Sanisidro, E. Cantero, J. Prado, M. Alberdi** NEW INSIGHTS ON THE DIVERSIFICATION OF HORSES
- 10:30** **L.N. Weaver, S.G. Chester, J.W. Crowell, T.R. Lyson** A SMALL ARCHAIC UNGULATE SKULL FROM THE EARLY PALEOCENE DENVER FORMATION OF COLORADO (CORRAL BLUFFS, EL PASO COUNTY)
- 10:45** **Z. Landry, M. Roloson, D. Fraser** INVESTIGATING THE RELIABILITY OF METAPODIALS AS TAXONOMIC INDICATORS FOR BERINGIAN HORSES
- 11:00** **J. Tissier, C. Balme, P. Coster, L. Costeur, O. Lapauze, S. Legal, O. Maridet, B. Mennecart, R. Roch, P. Röschli** THE LAST KNOWN PALAEOOTHERE: CONTRIBUTIONS OF NEWLY DISCOVERED REMAINS AND ENDOCRANIAL CHARACTERS TO THE PALAEOECOLOGY AND RECONSTRUCTION OF *PLAGIOLOPHUS HUERZELERI* (MAMMALIA, PERISSODACTYLA)
- 11:15** **B.M. Rothschild** PERISSODACTYLA KEEPING THEIR COOL: APPARENT VASCULAR PLEXUS-RELATED THERMOREGULATION, PRESENT AT LEAST SINCE THE PLEISTOCENE

- 11:30 **R.S. Paterson, M. Mackie, N. Rybczynski, D. Fraser, M. Gilbert, I. Patramanis, S. Liu, J. Ramos-Madrigal, R. MacPhee, E. Cappellini** AN EARLY MIOCENE ENAMEL PROTEOME OF AN EARLY-DIVERGING RHINOCEROTID FROM CANADA'S HIGH ARCTIC
- 11:45 **A. Khan, A. Rafeh, R. Ahmad, M. Waseem, A. Iqbal** MIDDLE MIOCENE UNGULATES FROM THE SIWALIK HILLS OF PAKISTAN: SYSTEMATIC AND BIOGEOGRAPHIC IMPLICATIONS
- 12:00 **O. Sanisidro, I. Arganda-Carreras, J.L. Cantalapiedra** A NEW METHOD TO TRANSLATE DENTAL COMPLEXITY OF HERBIVOROUS MAMMALS INTO NUMERICAL DESCRIPTORS: THE CASE STUDY OF HYPSONODONT RHINOS

**SATURDAY MORNING, NOVEMBER 5, 2022
TECHNICAL SESSION 17: FISH
MEETING ROOM METRO WEST
MODERATORS: Julia Türtscher and Jacob Wilson**

- 8:00 **T. Miyashita, M.I. Coates, K. Tietjen, P. Gueriau, P. Janvier** THE HEAD, HEART, AND FINS OF A JAWLESS STEM GNATHOSTOME
- 8:15 **R.A. Rivero-Vega, X. Cui, M. Zhu, M. Friedman** DIVERSIFICATION OF JAW GEOMETRY DURING THE INITIAL RADIATION OF LOBE-FINNED FISHES (OSTEICHTHYES: SARCOPTERYGII)
- 8:30 **A.M. Caron, M.I. Coates** *NEMATOPTYCHIUS*: A PALEOZOIC PIKE IN PARTS
- 8:45 **J.D. Wilson, T.R. Lyson, G.S. Bever** THE EARLY HISTORY OF ESOCIFORMES (TELEOSTEI) REVEALS CHALLENGES AND OPPORTUNITIES IN THE FOSSIL RECORD OF FRESHWATER FISH
- 9:00 **Z. Johanson, J. Liston, D. Davesne, T. Challands, M. Meredith Smith** MECHANISMS OF DERMAL BONE REPAIR AFTER PREDATORY ATTACK IN THE GIANT STEM-GROUP TELEOST *LEEDSICHTHYS PROBLEMATICUS* SMITH WOODWARD, 1889 (PACHYCORMIFORMES)
- 9:15 **A. Knapp, G. Rangel-de Lazaro, M. Friedman, S. Giles, K. Evans, A. Goswami, Z. Johanson** HOW TO TUNA FISH: HIGH PHENOTYPIC INTEGRATION AND STRONG PHYLOGENETIC SIGNAL SUGGEST NEUROCRANIUM SHAPE EVOLVED EARLY IN THE DIVERGENCE OF PELAGIARIAN FISHES
- 9:30 **C.D. Wilson, C.F. Mansky, J. Anderson** A NEW PREDATORY ACTINOPTERYGIAN FROM BLUE BEACH, NOVA SCOTIA
- 9:45 **S.K. Drumheller, F.R. O'Keefe, M. Mayhall, E. Stalker, C.A. Brochu** FISH ARE NEITHER FRIENDS, NOR FOOD: OSTEICHTHYAN PREDATION OF A SUBADULT PLESIOSAUR
- 10:15 **M. Amadori** TRACKING THE "KRAKEN-KILLER": RISE AND FALL OF CRETACEOUS ENIGMATIC DUROPHAGOUS SHARK *PTYCHODUS* (ELASMOBRANCHII, PTYCHODONTIDAE)
- 10:30 **J. Stack, M.D. Gottfried, M. Stocker** A NEW EARLY PERMIAN RAY-FINNED FISH (ACTINOPTERYGII) EXPOSES ROGUE TAXA THAT OBSCURE THE DIVERGENCE OF THE ACTINOPTERYGIAN CROWN GROUP
- 10:45 **L.J. Rose, J.P. Crothers, A.B. Heckert, S.J. Nesbitt, M. Stocker, B. Lauer, R. Lauer** OSTEICHTHYANS AND CHONDRICHTHYANS OF THE UPPER TRIASSIC HOMESTEAD SITE OF EAST-CENTRAL NEW MEXICO, U.S.A, ALONG WITH A COMPARISON OF LUNGFISH (SARCOPTERYGII: DIPNOI) TOOTH PLATES FROM OTHER TRIASSIC LOCALITIES ACROSS THE AMERICAN SOUTHWEST
- 11:00 **E. Villalobos-Segura, S. Stumpf, J. Kriwet** REASSESSMENT OF LATE JURASSIC ELASMOBRANCH FISHES
- 11:15 **P.L. Jambura, E. Villalobos-Segura, J. Türtscher, S. Klug, J.G. Maisey, G. Naylor, M.A. Staggli, S. Stumpf, J. Kriwet** RECONCILING GENETICS AND MORPHOLOGY: A REVISED PHYLOGENETIC ANALYSIS OF THE ENIGMATIC ELASMOBRANCH *PROTOSPINAX ANNECTANS* FROM THE LATE JURASSIC LAGERSTÄTTE OF SOLNHOFEN, GERMANY
- 11:30 **J. Türtscher, P.L. Jambura, E. Villalobos-Segura, D. Thies, J. Kriwet** NEW INSIGHTS INTO EXCEPTIONALLY PRESERVED LATE JURASSIC HOLOMORPHIC RAYS (CHONDRICHTHYES, BATOMORPHII) FROM EUROPE (SOLNHOFEN, CERIN, KIMMERIDGE)
- 11:45 **A. López-Arbarello, M. Ebert** CATURID (HALECOMORPHI, AMIIFORMES) DIVERSITY IN THE LATE JURASSIC

12:00 M.A. During, J. Smit, D.F. Voeten, C. Berruyer, P. Tafforeau, S. Sanchez, K.H. Stein, S. Verdegaal-Warmerdam, J.H. Van der Lubbe, P.E. Ahlberg ACIPENSERIFORM FISH FOSSILS REVEAL KPG IMPACT SEASON

SATURDAY AFTERNOON, NOVEMBER 5, 2022

TECHNICAL SESSION 18: BIRDS

MEETING ROOM METRO CENTRE

MODERATORS: Talia Lowi-Merri and Ryan Felice

- 1:45** C.R. Torres, J. Clarke, J.R. Groenke, M.C. Lamanna, R. MacPhee, G. Musser, E. Roberts, P.M. O'Connor NEARLY COMPLETE SKULL OF LATEST CRETACEOUS BIRD *VEGAVIS IAAI* PROVIDES NEW INSIGHTS ON FEEDING ECOLOGY AND NEUROANATOMY IN EARLY PHASES OF AVIAN CROWN GROUP DIVERSIFICATION
- 2:00** T. Lowi-Merri, O.E. Demuth, D.J. Field, R. Benson, S. Claramunt, D.C. Evans USING COMPARATIVE FUNCTIONAL MORPHOLOGY TO RECONSTRUCT LOCOMOTION IN THE CRETACEOUS BIRD *ICHTHYORNIS* (AVIALAE: ORNITHURAE)
- 2:15** C.V. Miller, M. Pittman, X. Wang, X. Zheng, J.A. Bright QUANTITATIVE INVESTIGATION OF MESOZOIC TOOTHED BIRD (PENGORNITHIDAE) DIET REVEALS EARLIEST EVIDENCE OF MACROCARNIVORY IN BIRDS
- 2:30** R.N. Felice, C.R. Torres, P.M. O'Connor, M.R. May TRAIT-DEPENDENT DIVERSIFICATION IN BIRDS ACROSS THE K-PG BOUNDARY AND THE IMPORTANCE OF FOSSIL DATA
- 2:45** P. Kuo, R. Benson, D.J. Field EVOLUTIONARY HISTORY OF BIRD MORPHOLOGY: USING 3D SCANS TO ESTIMATE ANCESTRAL STATES OF GALLOANSERAN QUADRATES
- 3:00** P. Houde, M. Dickson, D. Camarena NEW BASAL ANSERIFORMES FROM THE EARLY PALEOGENE OF NORTH AMERICA AND EUROPE
- 3:15** S. Giovanardi USING THE CONSTRUCTIONAL FRAMEWORK TO ASSESS MACROEVOLUTION: THE CASE OF FOSSIL PENGUINS
- 3:30** G. Navalon, L.M. Chiappe, A. Martinelli, W. Nava, D.J. Field THREE-DIMENSIONAL ENANTIORNITHINE BRAINCASE CLARIFIES THE ORIGIN OF THE CROWN BIRD ENDOCRANIUM
- 3:45** A. Chen THE EARLY EVOLUTION OF CROWN BIRDS: PHYLOGENETIC AND MORPHOLOGICAL CASE STUDIES
- 4:00** E. Steell, M. Chotard, D.J. Field EXTENSIVE HOMOPLASY IN THE APPENDICULAR SKELETON OF PASSERINE BIRDS

SATURDAY AFTERNOON, NOVEMBER 5, 2022

TECHNICAL SESSION 19: MARINE MAMMALS

MEETING ROOM METRO EAST

MODERATORS: Mark D. Uhen and Mark Clementz

- 1:45** A.S. Gohar, H. Woodward, H.M. Sallam, S. El-Sayed, M.S. Antar OSTEOHISTOLOGY OF *PHIOMICETUS ANUBIS* REVEALS UNIQUE LIFE HISTORY PATTERNS IN EARLY CETACEANS
- 2:00** WITHDRAWN
- 2:15** M.D. Nelson, O. Lambert, M.D. Uhen TAXONOMIC AND PHYLOGENETIC STUDY OF THE LATE OLIGOCENE HETERODONT ODONTOCETE *EOSQUALODON LANGEWIESCHEI* PROVIDES CLUES ABOUT THE EMERGENCE OF MODERN TOOTHED WHALES
- 2:30** A.M. Benites Palomino, G. Aguirre-Fernandez, J. Flynn, C. De Muizon, D. Ochoa, J. Tejada-Lara, A. Altamirano, P. Baby, R. Salas-Gismondi THE EARLY MARINE-FRESHWATER TRANSITION OF THE PLATANISTIDAE (CETACEA: ODONTOCETI) IN TROPICAL SOUTH AMERICA
- 2:45** M.M. Churchill, D. Xiong FEEDING ECOLOGY AND FUNCTION IN EXTINCT TOOTHED WHALES, AS INFERRED FROM THE AREA OF ATTACHMENT FOR THE TEMPORALIS MUSCLE

- 3:00 **A.M. Glass** CORRELATIONS BETWEEN CRANIAL AND INNER EAR MORPHOLOGIES OF ODONTOCETES
- 3:15 **WITHDRAWN**
- 3:30 **M. Clementz** INSIGHT INTO ANCIENT SEAGRASS COMMUNITIES FROM THE DIVERSITY AND ABUNDANCE OF THE SIRENIAN FOSSIL RECORD
- 3:45 **R. Laker** TRANSFORMING FOSSIL DIAGENESIS FROM A PROBLEM INTO A TOOL: MICROTAPHONOMIC FEATURES OF BONE REFLECT EARLY DEPOSITIONAL ENVIRONMENTS AND THUS THE DYNAMICS OF TIME-AVERAGING IN MIOCENE (CALVERT CLIFFS, MD) AND EOCENE (VALLEY OF THE WHALES, EGYPT) MARINE SILICICLASTIC RECORDS
- 4:00 **M.D. Uhen** ASSESSING COMMITMENT TO THE LIFE AQUATIC IN MAMMALS

**SATURDAY AFTERNOON, NOVEMBER 5, 2022
TECHNICAL SESSION 20: CROCODYLOMORPHA
MEETING ROOM METRO WEST
MODERATORS: John Fortner and Michela Johnson**

- 1:45 **M.M. Johnson, E. Maxwell** EVALUATING BODY SIZE DISTRIBUTION IN *MACROSPONDYLUS BOLLENSIS* (CROCODYLOMORPHA: TELEOSAUROIDEA) IN THE TOARCICAN POSIDONIA SHALE; GERMANY
- 2:00 **R.C. Allen, K. Chin** A CRETACEOUS PHOSPHATIC CONCRETION CONTAINING A SMALL CROCODYLIAN: WHEN A COPROLITE ORIGIN STINKS
- 2:15 **B.F. Mohler, A.T. McDonald, D.G. Wolfe** NEW CROCODYLOMORPH MATERIAL INCLUDING *BRACHYCHAMPSA* CF. *B. SEALEYI* AND CF. *DENAZINOSUCHUS* FROM THE ALLISON MEMBER OF THE MENEFFEE FORMATION, NEW MEXICO: AN EMERGING PICTURE OF SOUTHERN LARAMIDIAN CROCODYLOMORPH PALEOECOLOGY DURING THE CAMPANIAN
- 2:30 **K.I. Velez-Rosado, J.A. Wilson Mantilla, P. Gingerich** A NEW LONG-SNOUTED CROCODYLIAN (CROCODYLIA: GAVIALIDAE) FROM THE EOCENE DOMANDA FORMATION OF PAKISTAN SHEDS LIGHT ON THE EVOLUTIONARY AND PALEOBIOGEOGRAPHIC HISTORY OF GRYPOSUCHINES
- 2:45 **M. Riegler, L.W. Vinola, R.E. Narducci, M.C. Vallejo-Pareja, J. Pirlo, J.I. Bloch** CROCODYLIAN PREY EXCLUSIVITY AND THREE NEW ALLIGATOR SPECIES FROM THE MID TO LATE MIOCENE OF FLORIDA: INSIGHTS FROM GEOCHEMICAL DATA AND HIGH-RESOLUTION CT SCANS
- 3:00 **A. Erb, M. Young, J. Schwab, S. Walsh, L.M. Witmer, Y. Herrera, F. Vasconcellos, S.L. Brusatte** ENCEPHALIC BLOOD FLOW EVOLUTION IN THALATTOSUCHIAN CROCODYLOMORPHS
- 3:15 **C. Nicholl, E. Marwood, P. Burke, M. Mahboubi, D. Pol, P.D. Mannion** A NEW NOTOSUCHIAN CROCODYLIFORM PHYLOGENY: THE IMPORTANCE OF INCREASED CHARACTER AND TAXON SAMPLING VIA THE USE OF CONTINUOUS CHARACTERS AND STANDARDIZED CHARACTER CONSTRUCTION
- 3:30 **I. Scavezzoni, V. Fischer** THE DIVERSE YET NOT-SO-CONVERGENT TRANSFORMATIONS OF CROCODYLIFORMES TO THE AQUATIC REALM
- 3:45 **W. Gearty** THE COMPLEX HISTORY OF EXTINCTION AND ORIGINATION SELECTIVITY IN CROCODYLOMORPHA
- 4:00 **J.D. Fortner, K. Middleton, C. Holliday** BIOMECHANICS OF ALLIGATOR INTRAMANDIBULAR JOINTS AND ITS SIGNIFICANCE TO THEROPOD DINOSAURS

**SATURDAY AFTERNOON, NOVEMBER 5, 2022
REGULAR POSTER SESSION 4
MEETING ROOM FRONTENAC**

Authors must be present from 4:30 – 6:30 p.m. on Saturday, November 5

- B211** S. El-Sayed, M. Friedman, R. Speijer, B.S. Salem, H.M. Sallam AN EARLY PALEOCENE (DANIAN) RECORD OF MOONFISHES (CARANGARIA: MENIDAE), WITH IMPLICATIONS FOR EARLY DIVERSIFICATION IN CARANGARIAN FISHES
- B212** H. Saad, M. Friedman A PUTATIVE SPADEFISH (ACANTHOMORPHA: EPHIPPIDAE) FROM THE INDO-PACIFIC REGION AND ITS IMPLICATIONS FOR MARINE FISH BIOGEOGRAPHY IN THE PALEOGENE
- B213** T.D. Cook, L. Barmore SUBTLE YET SIGNIFICANT CHANGES IN ENAMELOID MICROSTRUCTURE OF *ARCHAEOLAMNA KOPINGENSIS* OVER TIME
- B215** D. Broussard, J. Trop, S. Hasiotis, P. Zippi PALEONTOLOGY AND SEDIMENTOLOGY OF LATE DEVONIAN VERTEBRATE-BEARING MARINE TO CONTINENTAL DEPOSITIONAL ENVIRONMENTS OF THE CATSKILL FORMATION, NORTH-CENTRAL PENNSYLVANIA, USA
- B216** A.K. Enny, A.M. Jukar DIVERSITY PATTERNS OF FRESHWATER TELEOST FISH IN THE CENOZOIC OF AFRICA
- B217** A.M. Baez PRELIMINARY REPORT ON RECENT FINDS FROM THE CENOMANIAN CANDELEROS FORMATION OF NORTHWESTERN PATAGONIA, ARGENTINA, AND THEIR BEARING ON THE EVOLUTION OF PIPIMORPH FROGS (ANURA, XENOANURA)
- B218** A. Woodruff, R. Coogan, R. Hulbert, J.I. Bloch SALAMANDERS (URODELA) FROM THE LATE MIOCENE TYNER FARM FOSSIL LOCALITY, ALACHUA COUNTY, FLORIDA
- B219** A.D. Apgar, C.P. Tomé, J. Moore, G.S. Weissmann A RECONSTRUCTION OF LATE TRIASSIC ASSEMBLAGES AND THEIR RESPONSE TO THE ADAMANIAN-REVUELTIAN FAUNAL TURNOVER
- B220** B. Slibeck, P. Olsen A NEW *RHYNCHOSAUROIDES* FROM THE UPPERMOST PASSAIC FORMATION OF THE NEWARK BASIN AND ITS PALEOECOLOGICAL SIGNIFICANCE
- B221** E. Armour Smith, Z.T. Kulik, A. Huttenlocker, C. Sidor ONTOGENY OF A NEW SHUVOSAURID (ARCHOSAURIA: PARACROCODYLOMORPHA) FROM THE UPPER TRIASSIC CHINLE FORMATION OF PETRIFIED FOREST NATIONAL PARK
- B222** M. Lacerda, M.A. de França, M.B. Soares ADDITIONAL POST-CRANIAL MATERIAL AND THE DISCOVERY SITE OF THE ERPETOSUCHID *PAGOSVENATOR CANDELARIENSIS*, FROM THE MIDDLE-LATE TRIASSIC OF BRAZIL.
- B223** E.S. Steinberg, H. Quintal, M. Riegler, L.W. Vinola FOSSIL HERPETOFAUNA OF PEDERNALES PROVINCE, DOMINICAN REPUBLIC: NOVEL RECORD OF HUMAN-INDUCED EXTINCTION AND EXTIRPATION
- B225** R. Coogan, A. Woodruff, R. Hulbert, J.I. Bloch EARLY HEMPHILLIAN (LATE MIOCENE) SNAKES FROM THE TYNER FARM FOSSIL LOCALITY OF NORTH CENTRAL FLORIDA
- B226** B. Adrian, H.F. Smith, K. Kelley, D.G. Wolfe FOSSIL TURTLES, INCLUDING A NEW BAENID, FROM THE LATE CRETACEOUS (TURONIAN) MORENO HILL FORMATION, NEW MEXICO, USA
- B227** D.W. Larson, M.J. Vavrek, D.B. Brinkman, J. Morin A NEW HELOCHELYDRID TURTLE (HELOCHELYDRIDAE; TESTUDINATA) FROM THE LATE CRETACEOUS OF BRITISH COLUMBIA, CANADA
- B228** C.J. Parrelly, C.A. Brochu, C. Boyd THE SYSTEMATICS AND PALEOECOLOGICAL SIGNIFICANCE OF A NEW GENERALIZED EUSUCHIAN FROM THE EARLY PALEOCENE OF NORTH DAKOTA
- B229** E. Wilberg, D. Pol, A. Turner THE PHYLOGENETIC RELATIONSHIPS OF CROCODYLOMORPHA: ADVANCES FROM AN EXPANDED PHENOTYPIC SUPERMATRIX
- B230** B. Holgado, R.A. Bantim, R. Buchmann, A.F. Araujo, A.Á. Saraiva, J.M. Sayão, A.W. Kellner ON A NEW CHAOYANGOPTERID PTEROSAUR SPECIMEN FROM THE LOWER CRETACEOUS CRATO FORMATION (ARARIPE BASIN, NE BRAZIL) WITH IMPLICATIONS ON THE INTRARELATIONSHIPS AND PALEOBIOGEOGRAPHY OF THIS CLADE

- B231** **I. Perea, E. Wolff, J. Moore** PTEROSAUR DEATH POSE PROVIDES INSIGHT INTO TAPHONOMY AND MODE OF MORTALITY
- B233** **C. Sullivan, T.A. Stidham, S. Buryak, C.K. West, J.K. O'Connor, A. Reyes, M.J. Vavrek, G. Zazula** A PROBABLE PHAETHONTIFORM BIRD FROM THE TERRESTRIAL MIDDLE EOCENE (BARTONIAN) OF YUKON, CANADA
- B234** **I. Garofalo, P. Houde** AN EXCEPTIONALLY WELL-PRESERVED HIGHER LANDBIRD FROM THE EARLY EOCENE LONDON CLAY
- B235** **G. Musser, J. Clarke** A NEW PALEOGENE FOSSIL AND A NEW DATASET FOR WATERFOWL (AVES: ANSERIFORMES) ELUCIDATE PHYLOGENY AND ECOLOGICAL EVOLUTION
- B236** **J. Cozart, G. Scofield, E.R. Przybyszewski** NEW MORRISON DINOSAUR BONEBED FROM THE SALT WASH MEMBER IN NORTHWESTERN COLORADO, USA
- B237** **B.C. Theurer, C. Sullivan, P. Currie** MORPHOLOGY AND ARTICULAR CONFIGURATION OF THE TARSUS IN CERATOPSID DINOSAURS AS REVEALED BY A COMPLETE LOWER HINDLIMB FROM THE BELLY RIVER GROUP OF SOUTHERN ALBERTA, CANADA
- B238** **H. Grudi, C. Forster** PRESERVED FEMORAL EPIPHYSES IN THE IGUANODONTIAN DINOSAUR *TENONTOSAURUS TILLETI*
- B239** **C.M. Brown** HORNCORE FRACTURE IN *ANCHICERATOPS* (ORNITHISCHIA, CERATOPSIDAE), AND THE OCCURRENCE OF PATHOLOGICAL HORN FRACTURES IN CERATOPSIDAE
- B240** **J. Fronimos, M. Mayes** AIR SPACE BEYOND VERTEBRAE: PNEUMATICITY PATTERNS IN THE RIBS AND ILIUM OF A CRETACEOUS TITANOSAUR SAUROPOD
- B241** **C.D. Boisvert, T. Oswald, R. Scheetz, B.B. Britt** IT'S A HARD KNOCK LIFE: PATHOLOGIES AND SCAVENGING MARKS ON AN *APATOSAURUS EXCELSUS* FROM THE BASAL BRUSHY BASIN MEMBER OF THE MORRISON FORMATION (TITHONIAN, LATE JURASSIC) NEAR MOAB, UTAH
- B242** **A.L. Acker, P.M. O'Connor, J.R. Groenke** A DIGITAL ATLAS OF THE ABELISAURID FOOT: NEW INSIGHTS FROM *MAJUNGASAURUS CRENATISSIMUS* (THEROPODA: ABELISAURIDAE) FROM THE LATE CRETACEOUS OF MADAGASCAR
- B243** **L.A. Rooney, J. Anné** FURCULA OR JUST A WISH BONE? A CALL FOR STANDARDIZATION IN THE IDENTIFICATION OF *T. REX* FURCULAE
- B244** **D. Maranga, D.C. Evans, J. Chen, R. Reisz** EXCEPTIONALLY PRESERVED MICRORAPTORINE FROM THE EARLY CRETACEOUS OF CHINA PROVIDES NEW DATA ON MORPHOLOGICAL VARIATION THROUGHOUT THE COMPLETE TOOTH ROW IN MICRORAPTORINAE
- B245** **E.A. Warshaw, D.W. Fowler** EVOLUTIONARY MODE IN DERIVED TYRANNOSAURINAE
- B246** **D. Rhoda, K.D. Angielczyk** DIVERSIFICATION OF THE RUMINANT SKULL ALONG AN EVOLUTIONARY LINE OF LEAST RESISTANCE
- B247** **E. Froehlich, S.S. Hopkins** A REVIEW OF THE CAMELIDS (TYLOPODA, MAMMALIA) FROM THE JUNTURA FORMATION (MIOCENE) OF EASTERN OREGON
- B249** **J.M. Rodgers, K. Tate-Jones** THE FIRST KNOWN MODERN WALRUS FROM OREGON: A DESCRIPTION OF A PARTIAL SKULL OF *ODOBENUS ROSMARENSIS* (MAMMALIA, CARNIVORA)
- B251** **S.P. Zack, K.D. Rose, M. O'Leary** NEW INFORMATION ON THE ENIGMATIC *WYOLESTES* AND THE AFFINITIES OF THE GENUS
- B252** **A. Luthra, L.W. Vinola** POPULATION VARIATION AND BIOGEOGRAPHY OF EXTINCT SPECIES OF RODENTS FROM THE ISLAND OF HISPANIOLA
- B253** **F. Socki, J.J. Caledo** THE EVOLUTION OF PROCUMBENCY IN GEOMORPHA: THE INFLUENCE OF LOCOMOTORY SPECIALIZATION
- B254** **I.K. Lundeen, O.C. Bertrand** ANATOMICAL VARIATION IN RESPIRATORY AND OLFACATORY TURBINATES IN EXTANT AND FOSSIL SCIUROID RODENTS

- B255** G.W. Flora ADDITIONAL SKULLS OF *BATHYOPSIS* (MAMMALIA, DINOCERATA) FROM THE BRIDGER BASIN, WYOMING AND THEIR IMPLICATIONS FOR SPECIES VARIATION WITHIN *BATHYOPSIS*
- B256** L. Kahn, Q. Li, Z. Tseng PALEOECOLOGICAL IMPLICATIONS OF NASAL TURBINATE MORPHOLOGY IN THE PALEOCENE MAMMAL *ERNANODON ANTELIOS*
- B257** H. Machado, C. Barrón-Ortiz, J. Arroyo-Cabrales, Z. Landry, A. Marín-Leyva, E. Scott, O. Cirilli, E.B. Davis, R. Bernor REVIEWING THE KNOWLEDGE OF NORTH AND CENTRAL AMERICAN *EQUUS*
- B258** M. Ameen, A. Khan, M. Waseem, R. Ahmad THE IMPACTS OF CLIMATIC AND VEGETATIONAL REGIME ON THE PALEOGEOGRAPHY OF MEGA HERBIVORES (PROBOSCIDEANS) OF THE SIWALIKS
- B259** C.J. Salcido, P. Polly FUNCTIONAL DRIVERS OF EVOLUTIONARY RATES IN MANDIBLE SHAPE OF CARNIVOROUS THERIAN MAMMALS: A STUDY USING BIOMECHANICAL MODELING AND GEOMETRIC MORPHOMETRICS
- B260** M.M. Gilbert, F. McDougall PALEOENVIRONMENTAL AND PALEOECOLOGIC RECONSTRUCTION OF THE CALF CREEK LOCALITY (CYPRESS HILLS FORMATION) IN SOUTHWESTERN SASKATCHEWAN, CANADA: RECONSTRUCTING CANADA'S MOST PROLIFIC PALEOGENE BONEBED
- B261** C. Gilmore A 3D PRINTING APPROACH TO MODELING MECHANICAL BEHAVIOR OF INDIVIDUAL VERTEBRAE FOR FUNCTIONAL ANALYSES OF FOSSIL SPECIMENS
- B262** S. Hellert, D. Grossnickle, G. Lloyd, C. Kammerer, K.D. Angielczyk A COMPREHENSIVE META-PHYLOGENY OF ALL NON-MAMMALIAFORM SYNAPSIDS: NEW TOOL FOR STUDIES OF MACROEVOLUTION IN THE FORERUNNERS OF MAMMALS
- B263** V.D. Paes Neto, M. Costa Santos, A. Fabrício Machado, C. Schultz, T. Rodrigues Simões, J. Cisneros, S.E. Pierce, F. Lima Pinheiro NEW INFORMATION ON THE CARNIVOROUS DINOCEPHALIAN *PAMPAPHONEUS BICCAI* (ANTEOSAURIDAE: SYODONTINAE) FROM THE LATE PERMIAN OF BRAZIL
- B264** J.P. Crothers, I. Pugh, L.J. Rose, A.B. Heckert, M. Toren PRINTING, PAINTING, AND PRESENTING LOST WORLDS: ART AND 3D PRINTING AS AN INEXPENSIVE TOOL FOR INCREASING THE ACCESSIBILITY OF VERTEBRATE FOSSILS IN EXHIBITIONS AND CLASSROOMS
- B265** S.S. Hopkins THE NEED FOR BROADER APPLICATION OF "DOBZHANSKY'S RULE" TO PALEOECOLOGICAL STUDIES

VIRTUAL POSTERS

- B266** H. Maisch, M. Becker, E. Kehrley THE NORTHERNMOST CENOZOIC ATLANTIC COASTAL PLAIN OCCURRENCE AND FIRST REPORT OF THE WHALE SHARK, *RHINCODON TYPUS* SMITH, 1829 FROM MONMOUTH COUNTY, NEW JERSEY, USA
- B267** J. Jia, J. Anderson, J. Jiang, W. Wu, N. Shubin, K. Gao PREAXIAL DOMINANCE IN THE DEVELOPMENT OF CARPUS/TARSUS OF SALAMANDERS AND IMPLICATIONS ON DIGIT REDUCTION DURING FIN-TO-LIMB TRANSITION
- B268** S. Chambi-Trowell, M.J. Benton, D. Whiteside, E. Rayfield HOW DOES ACRODONTY IMPACT ON THE TOOTH AND JAW MORPHOLOGY OF LIZARDS AND RHYNCHOCEPHALIANS?
- B269** S. Choi, H. Kim, I. Paik, Y. Park, H. Jung, X. Xu THE OLDEST CONFIRMED ARAGONITE IN THERMALLY ALTERED TURTLE EGGS OF THE HASANDONG FORMATION (APTIAN-ALBIAN), SOUTH KOREA
- B270** N.G. Pezzoni, S.J. Nesbitt, M. Stocker TRUNK VERTEBRAE OF A LAGERPETID (ARCHOSAURIA: PTEROSAURIFORMES) DOCUMENTS VARIATION AND POSSIBLE ANCESTRAL CONDITIONS IN THE VERTEBRAL MORPHOLOGY OF EARLY-DIVERGING ORNITHODIRANS
- B271** X. Wu, L.M. Witmer, S. Chatterjee, D. Cunningham A NEW BASAL CROCODYLOMORPH (ARCHOSAURIA: CROCODYLOMORPHA) FROM THE UPPER TRIASSIC OF TEXAS, USA
- B272** L. Micucci, D.C. Evans, M.J. Ryan REEVALUATING THE LEPTOCERATOPSID (CERATOPSIA) RECORD FROM THE CAMPANIAN OF ALBERTA, CANADA

- B273** **A. Prieto-Marquez, A.G. Sellés** AN ENDEMIC CURSORIAL STYRACOSTERNAN DINOSAUR FROM THE IBERO-ARMORICAN ISLAND OF THE LATEST CRETACEOUS EUROPEAN ARCHIPELAGO
- B274** **P. Mbatha, W.J. Sanders, P. Edome** COMPARATIVE MORPHOMETRIC STUDY OF PROBOSCIDEAN DENTITION FROM THE APAK MEMBER OF THE NACHUKUI FORMATION AT LOTHAGAM, KENYA
- B275** **G. Semperebon, J. Pirlo, J. Dudek** DIETARY HABITS AND TUSK USAGE OF NORTH AMERICAN SHOVEL-TUSKED GOMPHOTHERES: EVIDENCE FROM MICROWEAR OF MOLARS AND UPPER AND LOWER TUSKS
- B276** **V.A. Perez-Crespo, J. Arroyo-Cabrales, E. Cienfuegos-Alvarado, S. Rodríguez-Franco, C. Ortiz-Reyes, F. Otero** FEEDING HABITS OF COLUMBIAN MAMMOTH (*MAMMUTHUS COLUMBI*) FROM SANTA LUCÍA IV, STATE OF MÉXICO, MÉXICO
- B277** **S. Rodríguez-Franco, V.A. Perez-Crespo, C. Barrón-Ortiz, L. Córdoba-Barradas, J. Arroyo-Cabrales** DENTAL MESOWEAR ANALYSIS OF THE COLUMBIAN MAMMOTH (*MAMMUTHUS COLUMBI*) FROM TULTEPEC, ESTADO DE MÉXICO, MÉXICO
- B278** **T. Tsubamoto, H. Taru** A NEW SPECIMEN OF THE SUIDAE (MAMMALIA, ARTIODACTYLA) FROM THE UPPER MIOCENE OF JAPAN, AND A BRIEF REVIEW OF JAPANESE NEOGENE SUIDS
- B279** **R. Moya-Costa, À. Luján, I. Casanovas-Vilar** CRANIAL ANATOMY OF *MEGACRICETODON* (RODENTIA, MAMMALIA) AND IMPLICATIONS IN THE PHYLOGENY OF MIOCENE EUROPEAN MUROIDS
- B280** **A.K. Hunt, D. Ford, V. Fernandez, R. Benson** A DESCRIPTION OF THE PALATE AND MANDIBLE OF *YOUNGINA CAPENSIS* (SAUROPSIDA, DIAPSIDA) AND THE PHYLOGENETIC IMPLICATIONS
- B281** **S.C. Schlief, K. Brink** QUANTIFYING BONE GROWTH IN AN EXTANT REPTILIAN MODEL: IMPLICATIONS FOR HISTOLOGICAL STUDIES IN EXTINCT ANIMALS
- B282** **A.P. Cossette, D.A. Tarailo** A NEW CROCODYLIAN FROM THE PALEOCENE FORT UNION FORMATION OF SOUTHEASTERN MONTANA
- B283** **T. Tanaka, D. Brinkman, C. Tsai, D. Burnham, T. Tokaryk** A NEW SMALL HESPERORNITHIFORMES FROM THE SMOKY HILL MEMBER OF THE NIOBRARA FORMATION IN WESTERN KANSAS
- B284** **R. Duarte-Bigurra, A. Vicente, C. Gutiérrez-Blando, C. Serrano-Brañas, A. Prieto-Marquez** SAUROLOPHINE HADROSAURID (DINOSAURIA: ORNITHISCHIA) SPECIMENS FROM THE CABULLONA GROUP (LATE CRETACEOUS) OF NORTHEASTERN SONORA, MEXICO
- B285** **A.S. Brum, K.L. Bandeira, J.M. Sayão, D.D. Campos, A.W. Kellner** THE MICROSTRUCTURE OF RIBS IN LITHOSTROTIAN TITANOSAURS REVEALS DIFFERENCES IN THE TIMING OF BONE APPPOSITION FROM EARLY-DERIVING NEOSAUROPOD PATTERN
- B286** **J.B. Scannella, H. Woodward, E. Lamm, E. Wolff** LIFE HISTORY OF THE *ALLOSAURUS JIMMADSENI* SPECIMEN MOR 693 ("BIG AL") AS REVEALED BY TIBIAL HISTOLOGY
- B287** **T. Aureliano, M.A. Fernandes, A.M. Ghilardi** A NOASAURID THEROPOD FROM EASTERN AMAZONIA SHEDS LIGHT ON THE EVOLUTION OF THE PNEUMATICITY IN ABELISAUROIDS
- B288** **E. Isasmendi, E. Cuesta, I. Díaz-Martínez, P. Sáez-Benito, L.I. Viera, A. Torices, X. Pereda-Sueberbiola** LOWER CRETACEOUS SPINOSAURID REMAINS OF LA RIOJA (SPAIN): PRELIMINARY RESULTS OF THE CAMEROS PARTIAL SKELETON
- B289** **D. Surmik, F. Gäb, M. Kadziolka-Gawel, M. Dulski, M.P. Sander, J. Slowiak-Morkovina, T. Szczygielski, R. Pawlicki** RECYCLING HEMOGLOBIN? – PRESERVATION OF *TARBOSAURUS BATAAR* BONE MICROSTRUCTURES IN IRON OXIDES
- B290** **L. Sankau, D.R. Green, K.T. Uno, J. Rowan** NICHE PARTITIONING IN FOSSIL BOVIDS NEAR THE MIOPLIOCENE BOUNDARY AT LOTHAGAM, TURKANA BASIN, KENYA
- B291** **C. Lopez-Aguirre, S.J. Hand, A. Link** EPIPHYSEAL HUMERAL MORPHOLOGY REVEALS FORAGING ADAPTATIONS TO CARNIVORY IN AN EXTINCT BAT
- B292** **G.A. de Souza, A.S. Brum, B.A. Bulak, M.B. Soares, J.M. Sayão, A.W. Kellner** SHARK TEETH AND VERTEBRAE FROM THE MARAMBIO GROUP (UPPER CRETACEOUS) OF JAMES ROSS ISLAND, ANTARCTICA PENINSULA

- B293** H.T. Heusinkveld, J. Anderson THE RHIZODONTS OF BLUE BEACH, NOVA SCOTIA, CANADA (HORTON BLUFF FORMATION, TOURNASIAN): NEW DATA ON OCCURRENCES AND IMPLICATIONS FOR PHYLOGENY AT THE DEVONIAN-CARBONIFEROUS FAUNAL TRANSITION
- B294** T. Ikeda, H. Ota, T. Tanaka A PRELIMINARY REPORT OF ALBANERPETONTID AMPHIBIANS (AMPHIBIA: ALBANERPETONTIDAE) FROM THE LOWER CRETACEOUS OHYAMASHIMO FORMATION OF THE SASAYAMA GROUP, HYOGO, JAPAN
- B296** A. Zaborniak, L.E. Wilson DISTRIBUTION AND TOOTH MORPHOGUILDS OF MOSASAURIDS (SQUAMATA) OF THE CAMPANIAN WESTERN INTERIOR SEAWAY WITH IMPLICATIONS FOR CONTROLS ON MOSASAUR PALEOBIOGEOGRAPHY
- B297** Y. Liaw, C. Tsai NEW INTERPRETATIONS OF TWO LONG-FORGOTTEN FOSSIL TURTLES FROM THE PLEISTOCENE OF TAIWAN
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- B299** D. Schwimmer A MAASTRICHTIAN HADROSAUR FROM THE RIPLEY FORMATION, SOUTHWESTERN GEORGIA, USA
- B300** R. Bykowski MEGATHEROPOD MORPHOLOGIC DISPARITY AS A PROXY FOR UNDERSTANDING STRUCTURING OF MESOZOIC ECOSYSTEMS
- B301** A. Marsh, D. DeBlieux, J.I. Kirkland THE FIRST DINOSAUR SKELETAL FOSSILS FROM THE KAYENTA FORMATION OF UTAH
- B302** D. Barta, C. Griffin, D. Simon FIRST HISTOLOGICAL EVIDENCE OF A BONY ABNORMALITY FROM THE GHOST RANCH *COELOPHYSIS* QUARRY, NEW MEXICO: AN EXTERNALLY CRYPTIC EXOSTOSIS IN A *COELOPHYSIS BAURI* (DINOSAURIA: THEROPODA) TIBIA
- B303** Y. Kobayashi, R. Takasaki, A.R. Fiorillo, C. Tsogtobaatar, Y. Hikida NEW THERIZINOSAURID DINOSAUR FROM THE MARINE OSOUSHINAI FORMATION (UPPER CRETACEOUS, JAPAN) PROVIDES INSIGHT FOR FUNCTION AND EVOLUTION OF THERIZINOSAUR CLAWS
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- B306** Y. Kurono, N. Kohno ECOLOGICAL NICHE OF *HERPETOCETUS* (CETACEA, MYSTICETI) REVEALED FROM FUNCTIONAL MORPHOLOGY
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- B308** T.I. Pollock, O. Panagiotopoulou, N. Chatar, D.S. Rovinsky, J.W. Adams, D.P. Hocking, A.R. Evans TAKING A STAB AT MODELLING THE BIOMECHANICS OF SABRE-TEETH
- B309** L. Marilao, D. Barta, J. Fröbisch THREE-DIMENSIONAL MAXILLARY CANAL RECONSTRUCTION IN *COTYLORHYNCHUS ROMERI* (SYNAPSIDA: CASEIDAE) CLARIFIES THE BASAL SYNAPSID CONDITION
- B310** A.C. Morhardt, H. Jerison, C.M. Early, A. Farke DIGITIZED ENDOCASTS AND BRAINS: MEASUREMENTS AND ANALYSES OF THE EVOLUTION OF 172 FOSSIL AND EXTANT VERTEBRATE SPECIMENS
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- B313** C.D. Brownstein ISOLATED SKULL REVEALS A NEW TRIASSIC COELACANTH FROM TEXAS
- B314** C.D. Brownstein HIGH MORPHOLOGICAL DISPARITY IN A BIZARRE PALEOCENE FAUNA OF FRESHWATER REPTILES

- B315** **B.A. McBride, J. Lei, J. Zonneveld, A.H. Caruthers, V. Arbour** FIRST RHAETIAN-AGED ICHTHYOSAUR FROM THE PARDONET FORMATION OF BRITISH COLUMBIA, CANADA
- B316** **J.M. Bourke, P. Matulich, H.B. Campos** SOFT-TISSUE RECONSTRUCTION AND AIRFLOW THROUGH THE NASAL PASSAGES OF THE PTEROSAUR, *BARBOSANIA GRACILIROSTRIS*: IMPLICATIONS FOR RESPIRATORY PHYSIOLOGY, THERMOREGULATION, AND OLFACTION
- B317** **K. Koch, I. Cost** COMPARING CARDIOVASCULAR ANATOMY OF AVIAN SPECIES ACROSS FLYING STYLE
- B318** **J.A. Moretti, E. Johnson** THE PLIO-PLEISTOCENE AVIFAUNA OF ROLAND SPRINGS RANCH LOCALITY 1: PRELIMINARY ANALYSIS OF THE WATERBIRD ASSEMBLAGE
- B319** **K.L. Bandeira, A.W. Kellner** A REAPPRAISAL OF TITANOSAUR CLADISTIC ANALYSIS
- B320** **K.I. Watmore, D.R. Prothero, W. Gelnow** GIGANTIC SPERM WHALE TOOTH (CF. *LIVYATAN*) FROM THE MIOCENE OF SOUTHERN CALIFORNIA
- B321** **J.L. Kaiuca, M.B. Soares, W.C. Tavares** FOSSORIALITY IN THE CYNODONT-MAMMAL TRANSITION SCENERY: EVIDENCE FROM *BRASILODON QUADRANGULARIS*
- B322** **J. Jung, M. Huh** ICHNOLOGICAL EVIDENCE FOR A MULTI-AGED COLONY OF PTEROSAURS
- B323** **D. Landi, S. Singh, L. King, E. Rayfield, M.J. Benton** THE EVOLUTION OF BEAKS IN THE PERMIAN AND TRIASSIC
- B324** **M.R. Stout, M.F. Jones, K. Beard** ANALYSIS OF A PATHOLOGICAL COLUMBIAN MAMMOTH (*MAMMUTHUS COLUMBI*) THIRD MOLAR AND COMPARISONS TO OTHER PROBOSCIDEANS FROM CLARK COUNTY, KANSAS WITH IMPLICATIONS FOR PALEOECOLOGY AND DIET
- B325** **A.W. Kellner, A.T. Cavalcanti, T. Pinheiro, G.D. Machado, M. van Biene, J. Kunzler** MUSEU NACIONAL/UFRJ AFTER THE FIRE: THE CHALLENGES OF DEVELOPING A PALEOVERTEBRATE EXHIBITION INTEGRATED IN A CIRCUIT OF NATURAL HISTORY
- B326** **A. Ashbaugh, M. Summers, J.M. Theodor** WHAT DO YOU MEME? INVESTIGATING THE USE OF MEMES AS A LEARNING TOOL IN ZOOLOGY COURSES
- B327** **J. Ristevski** INSIDE THE HEAD OF ONE OF THE SMALLEST CROCODYLIANS: PALEOECOLOGICAL INSIGHTS FROM THE NEUROMORPHOLOGY OF *TRILOPHOSUCHUS RACKHAMI*, AND TRACING THE ORIGINS OF MEKOSUCHINAE
- B328** **C.M. Early** FILLING BRAIN SIZE ESTIMATE GAPS IN EXTINCT BIRDS
- B329** **D.P. Groenewald, R. Smith** SEARCHING FOR THE PERMO-TRIASSIC BOUNDARY IN KWAZULU-NATAL PROVINCE, SOUTH AFRICA
- B330** **M.D. Gottfried, A. Tennyson** A PLIOCENE BOXFISH FROM NEW ZEALAND -- A PREVIEW OF FUTURE ENVIRONMENTAL CHANGE?
- B331** **A.W. Kellner, L.D. David, B. Gonzalez Riga** ANATOMICAL PECULIARITIES OF THE GIANT PTEROSAUR *THANATOSDRAKON AMARU* (AZHDARCHIDAE, PTERODACTYLOIDEA) FROM UPPER CRETACEOUS DEPOSITS OF MENDOZA, ARGENTINA
- B332** **R. Lisle, K. Tate-Jones, E.B. Davis** STABLE ISOTOPE ANALYSIS OF LATE CRETACEOUS (MAASTRICHTIAN) SHARK TEETH (*SERRATOLAMNA SERRATA*; *CARCHARIAS* C.F. *HOLMDELENSIS*) FROM THE WESTERN INTERIOR SEAWAY
- B333** **S. Chakraborty, D.P. Sengupta, K. Halder** A NEW CROCODILE FROM THE EOCENE OF KUTCH BASIN, WESTERN INDIA
- B334** **M. Reichel-Bodner** THE POWER OF COLLABORATION: IMPROVING COMMUNICATION AND OUTREACH WITH INDUSTRY STAKEHOLDERS TO IMPROVE FOSSIL RECOVERY FROM AREAS IMPACTED BY URBAN DEVELOPMENT IN ALBERTA, CANADA
- B335** **M.A. Khan, A. Grossman, S.G. Abbas** NEW DENTAL REMAINS OF *ANISODON SALINUS* FROM THE POTWAR PLATEAU, PAKISTAN

B336 **J. Esteban Núñez, B. Figueirido, J.A. Pérez-Claros, A. Pérez-Ramos, A. Martín Serra** A 3D GEOMETRIC MORPHOMETRIC ANALYSIS OF THE SACRUM IN PINNIPEDS

Technical Session 11: Synapsida (Friday, November 4, 2022, 8:00 AM)

ONTOGENETIC MECHANISMS OF BODY SIZE CHANGE IN THE FOSSIL RECORD: IMPLICATIONS FOR THE LILLIPUT EFFECT AND A CASE STUDY OF *LYSTROSAURUS* AND *MOSCHORHINUS* IN THE KAROO BASIN, SOUTH AFRICA

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Body size is a widely studied aspect of phenotype in fossil organisms. Patterns of body size change, such as Bergman's Rule, Cope's Rule, Island Rule, and the Lilliput Effect (LE), have long interested paleobiologists. Size alone insufficiently evaluates the biological processes at work in these phenomena however, and additional metrics are needed to understand them. This can be accomplished with existing macroevolutionary methods, like the frameworks for heterochrony developed in the late 20th century. Ontogenetic models such as the "age-size-shape" space developed by Pere Alberch and colleagues facilitate comparison and quantification of ontogenetic trajectories among populations, providing insight into mechanisms underlying size change. An ideal application of this approach is the LE, a commonly documented but poorly understood pattern of body size reduction during extinctions. The LE is widely documented across clades and geologic time, but little is known of the processes that generate it. Ontogenetic shifts are worth investigating in examples of the LE, given that some LE taxa display "immature" phenotypes, including the original example of the LE. Historically, three patterns have been described as the LE: the removal of large taxa, the origination of smaller taxa, and within lineage size decrease. Though useful in documenting the effects of extinctions, on their own these patterns do not elucidate mechanisms underlying observed size decreases. Here we present refinements to the LE to remedy this shortcoming. First, the LE should be evaluated in a lineage context, either within a single species or with reference to phylogeny. Second, the LE is better described by inclusion of proximal mechanisms, including ontogenetic shifts and size-selectivity, which represent disparate responses to ultimate causes like lower resource availability or environmental stress. To evaluate these proximal mechanisms, we return to the "age-size-shape" framework. Two examples include *Lystrosaurus* species and *Moschorhinus kitchingi*, well-studied therapsids of the End Permian Mass Extinction that are abundant in the Karoo Basin, South Africa. Both taxa show clear decreased size and lifespan post-extinction, but their ontogenetic shape changes

are yet to be quantified. Preliminary application of our framework suggests the retention of immature phenotypes in these post-extinction taxa, but further analysis is needed to quantitatively link changes in shape, size, and age.

Funding Sources U.S. Dept of Education GAANN Grant P200A210054, Evolutionary Environmental Biology

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

A DIGITAL ATLAS OF THE ABELISAURID FOOT: NEW INSIGHTS FROM *MAJUNGASAUROUS CRENATISSIMUS* (THEROPODA: ABELISAURIDAE) FROM THE LATE CRETACEOUS OF MADAGASCAR

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Late Cretaceous Gondwanan continental ecosystems are dominated by abelisaurids among non-avian theropods. Although many abelisaurid taxa are based on relatively complete specimens, there remain some regions of the skeleton that are not preserved well or at all. The abelisaurid foot is known only in moderate detail from a limited number of taxa (*e.g.*, *Eoabelisaurus*, *Aucasaurus*, and *Skorpiovenator*). Detailed anatomy of the hind limb in *Majungasaurus* is lacking due to the incomplete nature of this region of the skeleton, limiting inferences related to hind limb-based body size proxies and locomotor biology more generally. Moreover, previous descriptions of the foot in *Majungasaurus* have relied on composite descriptions derived from partially associated-to-isolated specimens from different localities.

Here we report the recovery of associated hind limbs from an exquisitely preserved skeleton, including for the first time a nearly-complete foot of this important Maastrichtian abelisaurid. The specimen includes both right and left pelvic girdles and the associated hind limb skeleton, with most individual bones represented on at least one of the two feet. Metatarsals II-IV are preserved on both the left and right side, along with a near-complete phalangeal series (missing only phalanx I-1) on the right side. In addition to providing the first associated pedal remains, the new specimen augments previous descriptions by importantly preserving MT I and phalanx III-4, providing an ability to characterize and digitally model the entire foot in both neutral anatomical and inferred life-position (*i.e.*, in contact with the substrate) contexts.

Majungasaurus displays pedal characteristics consistent with other abelisaurids, including a non-pronounced flexor tubercle on the unguals, a proximal ventral depression on the

unguals[OP1] , and a laterally placed hyper extensor pit on the dorsal surface of digit IV-1. Hyper extensor pits on MT II-IV appear better developed in *Majungasaurus* than in other abelisaurids. The new specimen exhibits a strong lateral divergence of MT IV characteristic of *Majungasaurus*. Novel digital models of individual foot bones and the reconstructed foot of this specimen provide important comparative data for phylogenetic and functional students of this widespread Cretaceous lineage.

Funding Sources National Science Foundation
EAR_1664432.

Regular Poster Session 1 (Wednesday, November 2, 2022,
4:30 - 6:30 PM)

**NO SWIMMING DINOSAURS HERE: NEW INSIGHTS
ON MANUS-DOMINATED DINOSAUR TRACKS
FROM THE MAYAN DUDE RANCH IN BANDERA,
TEXAS**

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Since their initial discovery in the early part of the 20th century, the manus-only dinosaur trackway situated on the Mayan Dude Ranch in South Texas had been interpreted as evidence of swimming behavior in sauropods. The absence of pes impressions was explained as a partially buoyant trackmaker propelling itself with its forelimbs. Traditionally, this site has provoked much debate about the preservation of manus-only and manus-dominated tracksites, as well as our understanding of sauropod locomotion and behavior. Discussions have primarily focused on whether these unique trace fossils are a result of a swimming or submerged sauropod or that described manus-dominated trackways could be simply underprints.

Recent discoveries at R. T. Bird's famous 'swimming brontosaurus' site has resulted in 7 additional footprints in Bird's original sauropod trail, as well as a second manus-dominated sauropod trackway and a single isolated theropod track. A new study applying traditional ichnological and photogrammetric methods to record the historic site, along with microscopy and geochemical analyses of the lithology, provides a new

understanding of the paleoenvironment and preservational conditions at the time these tracks were formed. The study found that the second manus-dominated sauropod trackway records partial pes impressions with 4 of the 5 steps preserved. Along with the single theropod track, this would indicate these individuals were not being buoyed up by deeper water and kicking off the bottom with their forelimbs. In addition, linear symmetrical ripples with an average wavelength of 6.5 cm indicate wave agitation in shallow waters less than one meter deep. Microbial laminite with desiccation cracks occur 5 cm above the track surface indicating shoaling and subaerial emergence on a tidal flat. This depositional evidence demonstrates exceedingly shallow-water conditions and partial marine lithification of the substrate, hence ruling out a swimming sauropod origin of the tracks. As a result, we can definitively state that the dinosaur tracks preserved at the Mayan Dude Ranch are best interpreted as having an undertrack origin.

Funding Sources This study was supported by grants from the U.S. National Science Foundation (Rapid- EAR-2035478 and Rapid- EAR-2035529).

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 -
6:30 PM)

**A HIGH FREQUENCY OF FOSSIL TOOTH MARKS
FROM THE CEDAR MOUNTAIN FORMATION OF
UTAH**

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Tooth marks on Mesozoic fossils were traditionally considered rare traces, but intensive, site-wide surveys of bones within the Mygatt-Moore Quarry of the Morrison Formation have shown that they can be much more common than previously thought. These results relied on methods that have yet to be replicated in other Mesozoic sites. This makes direct comparisons between localities difficult and calls into question whether the unusually high frequency of traces are the result of unique paleoecological conditions, or a consequence of collection protocols and/or mark surveying techniques. Here, we replicated these methods using collections from the Cedar Mountain Formation of Utah to determine if similar techniques will result in a high frequency of tooth marks in these assemblages. Fossils from two quarries, the Dalton Wells and the Long Walk, were surveyed for marks using raking light and a 30x hand lens. Fossil in a range of conditions were sampled, as long as at least 30% of the bone surface was preserved and exposed. Tooth marks were readily distinguished from trample, insect, root, and preparation marks, by using established terminology and diagnostic

criteria from the taphonomic, forensic, and anthropology literature. Marks were then categorized, and their lengths were measured using digital calipers. The preserved weathering stage of the bones were also documented. Results show a similar frequency of tooth marks to the previous Morrison study, occurring on 20.8-26.7% of the 282 fossil fragments surveyed. Scores, many of which were shallow and faint, were the most common tooth marks (67.6%). These were followed by furrows (15.8%), pits (14.0%), and punctures (2.7%). All types of marks were found on fossils in low weathering stages, but only furrows and pits were on those with greater weathering. Sauropod, theropod, iguanodontid, and turtle remains all possessed marks, but no striated marks were found, making diagnosing the trace maker challenging. We attribute most marks to either medium sized theropods such as *Utahraptor*, or crocodyliforms. This study further supports that through intense survey methods, Mesozoic fossils can yield numerous traces and revise previous hypotheses of site taphonomy. This suggests the intensity of bone surface modification seen here may be normal and expected among Mesozoic, terrestrial remains that were exposed to scavenging and predation for an extended period of time.

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

FOSSIL TURTLES, INCLUDING A NEW BAENID, FROM THE LATE CRETACEOUS (TURONIAN) MORENO HILL FORMATION, NEW MEXICO, USA

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We describe the first Turonian baenid turtle from the Moreno Hill Formation in western New Mexico, which is located within a temporal hiatus for the clade of approximately 12 million years. The new taxon is preserved by a partial carapace, nearly complete plastron, and bridge elements. It was retrieved in a phylogenetic analysis as sister to the well understood basal baenid (derived baenid) *Plesiobaena antiqua* from the Campanian of Montana and Alberta, with which it is morphologically similar. Our phylogenetic analysis retrieves the two as sister taxa, forming a “*Plesiobaena*-grade” clade that is more basal within the derived clade Baenodda than all taxa except *Arvinachelys goldeni* from the Kaiparowits Formation of southern Utah. The new taxon is also basal to the two main clades of derived baenids, Palatobaeninae and Eubaeninae. The paleogeography of the middle Turonian Moreno Hill Formation is important, as it suggests a southern Laramidian origin for Baenodda. It is (along with the Menefee Formation) younger and stratigraphically continuous with the Fruitland and Kirtland formations, which are among the most productive Upper

Cretaceous sites in western North America. New material of the endemic helochelyrid stem turtle *Naomichelys* and a trionychid resembling “*Aspideretoides*” are also described, as are several ichnotaxa on the type specimen of the new taxon. The Moreno Hill Formation fossil turtle assemblage contains relict, derived, and immigrant components that are transitional between typical Early and Late Cretaceous faunas. Preliminary comparisons are made between the Moreno Hill Formation turtle assemblage and those of later San Juan Basin fossil sites, showing significantly greater baenid diversity in younger strata, the presence of the trionychid “*Aspideretoides*” group throughout, and *Naomichelys*, which is also known from the younger Menefee Formation.

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

IMPACT OF THE MIOCENE TO PLEISTOCENE ENVIRONMENTAL CHANGES ON THE ARTIODACTYL FAMILIES OF THE SIWALIK SUBGROUP OF PAKISTAN: ENAMEL HYPOPLASIA BASED STUDY

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The ecological responses of the Siwalik artiodactyls to Miocene through Pleistocene vegetational and climatic changes in the Siwalik subgroup of Pakistan are traced out in this study by using enamel hypoplasia (a dental defect) as an ecological and/or physiological stress marker. The dental remains of the families Giraffidae, Tragulidae, Cervidae, Hippopotamidae, Anthracotheriidae, Suidae, and Bovidae are analyzed in this study. This analysis uses 848 teeth from 487 extinct individuals belonging to 39 artiodactyl species in order to trace the influence of Neogene and Quaternary stress events on these animals. The analyzed material is part of the paleontological collection of the Institute of Zoology, University of the Punjab, Lahore, Pakistan. This is the first ever order-level investigation of enamel hypoplasia in the Siwalik artiodactyls. The results of this research illustrate that the early Pliocene Siwalik tragulids had high rates of enamel hypoplasia as compared to the middle Miocene Siwalik tragulids ($p < 0.05$) because tragulids prefer warmer ecosystems. There was a significant rise in the frequency of enamel hypoplasia for the Siwalik cervids during the Pliocene epoch ($p < 0.05$) due to drier and colder ecological circumstances along with an increase in seasonality. There was a high occurrence of enamel hypoplasias in the anthracotheroids from the Siwaliks region representing a continuous high level of stress that might be related to the global extinction of this family. The current enamel hypoplasia results indicates an increase in stress for Siwalik

hippopotamids during the late Pliocene. Enamel hypoplasia results of the analyzed Siwalik artiodactyls indicates a moderate level of stress for Siwalik giraffids, suids, and bovids, with no significant difference in occurrence of this dental defect during the different geological intervals of the Siwalik. Multiple linear enamel hypoplasia in the dental remains of the Pliocene Siwalik artiodactyls is high, indicating that Pliocene climatic changes in the Siwaliks were episodic in nature. The enamel hypoplasia results conclude that the C3 to C4 vegetational transitions were induced by increasing seasonality, aridity, and glacier occurrences, which may have presented a significant amount of stress to these Siwalik artiodactyls, resulting in diversification and extinction of numerous artiodactyl species in the Siwalik region.

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

A NEW LATE EOCENE HYSTRICOGNATHOUS RODENT (PHIOMORPHA) FROM THE JEBEL QATRANI FORMATION, FAYUM DEPRESSION OF EGYPT

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The Fayum Depression of Egypt yields a near-continuous record of terrestrial mammal evolution from the early late Eocene through the early Oligocene. Hystricognathous rodents are one of the most common lineages from the Fayum. Hystricognathi are abundant but not taxonomically diverse at Locality BQ-2, the oldest quarry in the Fayum (late Eocene, ~37 Ma). At Quarry L-41 (latest Eocene, ~34 Ma), the oldest productive vertebrate fossil locality in the lower sequence of the Jebel Qatrani Formation, taxonomic diversity is quite high just prior to Eocene-Oligocene boundary. Here we report new phiomorph fossils from Quarry L-41. These specimens document almost complete crania, several partial maxillae

with the entire upper dentition, and a mandible housing the complete dentition from P₄ to M₃. The new specimens differ from other phiomorph rodents by exhibiting the following features in combination: relatively small size, no repression of P₄ formation and eruption, in addition to the lack of a complete mesolophule, metalophulid I, and mesostylid. Moreover, the upper tooth row shows variation in the double connection of the lingual end of the metaloph with the mesolophule and the posteroloph; the anterior molars lack this connection whereas it is present in the distal molars. The dP⁴ is tetralophodont. The posteroloph ends at the distal part of the metacone and there is no trace of the anterocingulum. The M² lacks the complete mesolophule and mesostyle. There is no endoloph on M³. The P₄ has a simple pattern; the metalophulid II is short and doesn't reach the lingual wall. Overall, the species is most similar to other basal stem phiomorphs such as *Acritophiomys*, and attests to the existence of high taxonomic diversity among stem phiomorphs in northern Africa just prior to the onset of climatic change at the Eocene-Oligocene boundary. The new material allows us to expand the morphological character sample with new cranial characters that will enhance our understanding of the phylogenetic relationships of Hystricognathi.

Funding Sources Mansoura University, American University in Cairo Intramural grant

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

IT'S THE LITTLE THINGS IN LIFE: USING MICROFOSSILS TO EXPAND THE KNOWN VERTEBRATE CENSUS OF THE CRETACEOUS BLACKLEAF FORMATION IN SOUTHWEST MONTANA

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BL-1 is an early-Late Cretaceous fossil-bearing locality nestled within the Blackleaf Formation near the Lima Peaks study area in southwestern Montana. Previous examinations of BL-1 have produced a remarkable view into this otherwise unknown point in time. Microfossils in particular have been useful in expanding the known vertebrate diversity of this area, including crocodylians, fish, turtles, and dinosaurs. This past summer, MSU undergraduates were able to find more microfossils from this locality and describe the associated stratigraphy. Teeth are by far the most complete and abundant microfossil present at this locality, and are used as a means to expand the vertebrate census from the Ullmann et al. 2011 study, while also revising the geologic interpretation of the microsite, placing it in the younger Vaughn member associated with periodic input from fluvial systems and volcanic detritus.

Preliminary examination of the crocodylian teeth has warranted the inclusion of the non-eusuchian neosuchian

families Atoposauridae and Pholidosauridae to the census, as well as pycnodontiform fish, with implications for potential freshwater affinities. An examination of theropod teeth via multivariate analysis and morphological observations suggest an increase in theropod diversity apart from Dromaeosauridae and Tyrannosauroidae, with the potential presence of Troodontidae and an indeterminate tooth form.

This project highlights the value of micropaleontology as a means to extract key paleoecological data when large vertebrate material is biased against or otherwise scarce. Refining these methods to better establish Cretaceous faunal assemblages helps reveal major milestones in evolutionary trends between better-known formations and faunas.

Technical Session 20: Crocodylomorpha (Saturday, November 5, 2022, 1:45 PM)

A CRETACEOUS PHOSPHATIC CONCRETION CONTAINING A SMALL CROCODYLIAN: WHEN A COPROLITE ORIGIN STINKS

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Phosphatic concretions in terrestrial settings have traditionally been identified as coprolites based upon their biotic contents and heightened phosphorus levels relative to the global average in terrestrial sediments. However, recent discoveries have shown that nonfecal origins of phosphatic concretions are more common than originally recognized, and often contain well-preserved fossil remains. Here we examine a phosphatic concretion containing a small crocodylian from the Upper Cretaceous Hell Creek Formation of Montana to assess its likely origin and paleobiological implications. The geochemistry of the concretion was analyzed and neutron computed tomography (CT) was used to assess the skull-bearing portion of the concretion. The phosphatic chemistry, skeletal contents, and nearly two-liter total volume are consistent with a possible fecal origin. However, the completeness and distribution of the included bones, slightly elevated phosphorus concentrations in the surrounding sediment, and prevalence of clastic grains present a stronger case that the concretion had a nonfecal origin. Neutron CT analysis of the crocodylian's skull revealed a broad, blunt rostrum, enlarged fifth maxillary teeth, and globidont back teeth that permit its referral to *Brachychampsa montana*. Moreover, the ~10 cm length of the skull and comparisons with extant crocodylian growth curves suggest this was a juvenile with an estimated total body length of 55-90 cm and an age of less than five years old. The relatively complete cranial remains permit inferences on the juvenile's diet and life habits. Its globidont teeth would have facilitated durophagous feeding on prey items such as mollusks. The fine-grained depositional context of the concretion is relevant

to interpreting the crocodylian's preservation and habitat. The inferred nonfecal origin suggests *in situ* death and preservation of the crocodylian with minimal transport, whereas a coprolite interpretation would have indicated transport and both oral and digestive alteration via a predator. It also hints that the juvenile inhabited low-energy, shallow-water settings like extant juvenile crocodylians do for the sake of food and predator avoidance. Although it can be difficult to differentiate coprolites from non-fecal concretions, certain features reflect differences in origin and can dictate the types of available information; in this case, we gain insights on taxonomy and paleobiology that are less accessible in a coprolite.

Funding Sources The University of Colorado Boulder Museum of Natural History, and the Dudley and Marion Bolyard Scholarship for the Rocky Mountain Association of Geologists.

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

DEVELOPING A SCALING METHOD TO ESTIMATE THE CENTER OF MASS IN DINOSAURS

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The center of mass (CoM) is a fundamental mass property that, in animals, relates to key biomechanical factors such as stability, posture, and locomotion. Accordingly, CoM estimates of extinct organisms, like dinosaurs, offer the opportunity to reconstruct the biology of long-gone *Baupläne* and their macroevolutionary dynamics. Various physical and digital methods have been proposed to estimate CoM, but these require mostly complete skeletons, limiting the sample sizes of current data sets. Hence, there is a need to explore a comparatively simpler process to estimate the CoM in a larger range of taxa.

Here, a data set of 40 non-avian dinosaurs is used to explore the relationship between prior estimates of CoM and various indices based on relative humeral and femoral circumferences. These data are limited to taxa with confident and consistent CoM estimates and circumference measurements. Given the strong relationship between stylopodial circumferences and body mass in quadrupeds, we expect the relative magnitudes of these circumferences to represent the relative amount of mass that the forelimbs and hindlimbs bear.

Linear models recovered a significant relationship between relative stylopodial circumferences and CoM, but with substantial residual variance. By contrast, a significantly better fit was recovered if high-level clade belonging (i.e.,

Theropoda, Sauropodomorpha, and Ornithischia) was included in the model. Notably, incorporating a species-level phylogenetic correlation structure did not improve the model fit. The relationship between CoM and relative stylopodial circumferences was especially significant within sauropodomorphs but less so among ornithischians and theropods. Such clade-level differences may be attributed to a more consistent sauropodomorph *Bauplan* than ornithischians, with a greater variety of *Baupläne*, including multiple transitions to quadrupedality. In theropods, the evolution of flight and associated CoM shifts likely drive the residual variance we found, although sampling is also an issue. The differential patterns indicate that high-level clade belonging needs to be considered before applying this model. With this caveat in mind, we propose that relative humeral and femoral circumferences can serve as a general proxy for CoM, allowing for its inference beyond mostly complete skeletons.

Funding Sources Australian Research Council Discovery Early Career Research Award to NC (DE190101423)

Technical Session 17: Fish (Saturday, November 5, 2022, 8:00 AM)

TRACKING THE “KRAKEN-KILLER”: RISE AND FALL OF CRETACEOUS ENIGMATIC DUROPHAGOUS SHARK *PTYCHODUS* (ELASMOBRANCHII, PTYCHODONTIDAE)

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Ptychodus was an almost ubiquitous shark, which dominated the marine environments during the Late Cretaceous. Although *Ptychodus* is well known from the Cenomanian to Campanian of America, Europe, Africa and Asia, the exact stratigraphic distribution of this elasmobranch shark still is ambiguous and strongly debated. Pavement-like dentitions composed of non-cuspidate to cuspidate teeth and dental wear suggest *Ptychodus* mainly fed on ammonites and, more rarely, on other hard-shelled and/or soft-body prey. Elongated jaws and crushing tooth plates typical of today's small durophagous mesopredators combined with body size common among the large top predators of modern oceans gave this extinct shark a unique mix of anatomic traits. A temporal distribution analysis of *Ptychodus* species throughout the Cretaceous is presented here in a paleobiogeographic context. Due to the fragmentary nature of the fossil record of *Ptychodus*, known isolated, associated and articulated teeth from Lower and Upper Cretaceous deposits have been mainly considered to address diversity patterns of this durophagous predator and to identify possible biotic and abiotic drivers, but also to reflect its extinction before the K/Pg boundary event. The biostratigraphic and biogeographic reconstructions confirm an almost ubiquitous distribution of *Ptychodus* species during the Late Cretaceous, with a possible initial rise in the lower-middle Albian and a final demise in the middle to upper

Campanian. The results also indicate that this durophagous predator was most successful in terms of species diversity during the lower Turonian to lower Coniacian in offshore environments and continental shelf areas. Although the evolutionary history and distribution of *Ptychodus* was probably correlated with multiple biotic and abiotic factors, a possible lack of preferred prey is hypothesized here as a major trigger for the gradual decline of these durophagous predators. The present study thus lays the foundations for clarifying the effects of environmental changes on specialized elasmobranchs over long temporal scales and identifying possible extrinsic stressors underlying evolutionary changes. Consequently, my results help in establishing evolutionary models for durophagous elasmobranchs in general and for understanding the significance of durophagous feeding adaptations in marine ecosystems within the complex evolutionary history of sharks.

Funding Sources Austrian Science Fund (FWF) [33820]

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

THE IMPACTS OF CLIMATIC AND VEGETATIONAL REGIME ON THE PALEO GEOGRAPHY OF MEGA HERBIVORES (PROBOSCIDEANS) OF THE SIWALIKS

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Climate is the key element in defining vegetational regime and species ecology. Earth's geological history is crowded with vegetational turnover where adaptability of different species varied. Stable isotopes of carbon and oxygen are the proxies important in paleodiet and paleoecology studies. This study coined the linkage of paleodiet to the stable isotopes of carbon and oxygen using tooth enamel of fossil proboscideans (15.2–1.6 Ma) from the Siwaliks of northern Pakistan. The trial included a total of 69 samples from 50 individual quarries belonging to 15 species, 9 genera, and 4 families of the extinct proboscideans. The samples were pretreated and sent to PINSTECH (Pakistan Institute of Nuclear Science and Technology, Islamabad) for carbon and oxygen isotopic analysis. The depleted values of carbon and oxygen in deinotheriids indicate that this family preferred the warm and humid climate present in the Middle Miocene, with dense forest ecology, relied on soft vegetation like C₃ plants, and failed to survive in the grassland ecology of the early Late Miocene (~10–9 Ma) that started replacing forestland at the post-*Sivapithecus* interval (after 9.0 Ma). Gomphotheres and stegodontids have approximately similar values of carbon and oxygen. These proboscideans were present in woodland

habitat with dominant C₄ grasslands and survived through warm and dry climatic conditions of the Late Miocene, but were unable to sustain the cool and dry climate of the Plio-Pleistocene when grasslands were more abundant. Conversely, elephantids were successful in drier conditions of the Plio-Pleistocene, with almost equal values of carbon and oxygen during the Pliocene and the Pleistocene, respectively. These animals utilized the exclusive C₄ diet in open grasslands as successful grazers, indicated also by their tooth morphology. The outcomes of exertion shows that the gradual enrichment in mean values of carbon and oxygen recorded for the Late Miocene towards the Plio-Pleistocene indicate reduction in mean annual precipitation with increased aridity and progressive increase in C₄ vegetation with more open woodlands/grassland ecosystem. The climate changed from warm and humid to cold and dry conditions in the Siwaliks, where increased seasonality was too rapid for proboscideans to evolve in the region and exposed them to migration or extinction.

Funding Sources University of the Punjab, Lahore; University of Sialkot, Sialkot, Pakistan

Technical Session 11: Synapsida (Friday, November 4, 2022, 8:00 AM)

STRATIGRAPHIC AND GEOGRAPHIC OCCURRENCES OF PERMO-TRIASSIC TETRAPODS IN THE BOGDA MOUNTAINS, NW CHINA: IMPLICATIONS OF A NEW CYCLOSTRATIGRAPHIC FRAMEWORK AND BAYESIAN AGE MODEL

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The Junggar and Turpan basins of Xinjiang, northwest China, host a well-preserved terrestrial Permo-Triassic boundary sequence exposed on the flanks of the Bogda Mountains. During the Permo-Triassic, this region was located in mid-latitude northeast Pangaea (~45°N), making it an important comparison to the higher latitude record preserved in the South African Karoo Basin (~60°S). Broad similarities exist between the tetrapod records of both areas, such as the reported co-occurrence of *Dicynodon*-grade dicynodontoids and *Lystrosaurus* in the upper Permian and the high abundance of *Lystrosaurus* in the Lower Triassic. In the Bogda sections, the Permo-Triassic boundary falls within the upper Guodikeng Formation (= upper Wutonggou low order cycle), but several horizons have been proposed based on

biostratigraphy, chemostratigraphy, and paleomagnetic data. A new Bayesian age model calibrated by multiple radiometric dates and tied to detailed litho- and cyclostratigraphic data offers new insight into the location of the Permo-Triassic boundary in Xinjiang and the opportunity to reconsider tetrapod occurrences in a highly resolved chronostratigraphic framework. We investigated the positions of new and historic tetrapod specimens relative to the revised Permo-Triassic boundary, including uncertainties about the locations of key historic specimens. The stratigraphic range of *Dicynodon*-grade dicynodontoids in Xinjiang is poorly constrained: most specimens, including the holotype of *Jimusaria sinkianensis*, cannot be precisely placed relative to the Permo-Triassic boundary. A new specimen of *Turfanodon* sp. for which we have reliable data occurs in the upper Permian. Despite their previous treatment as Permian in age, most Bogda chroniosuchians were collected in strata above the Permo-Triassic boundary and the therocephalian *Dalongkoua fuae* also may be Triassic. Some prior placements of the Permo-Triassic boundary in Xinjiang imply an upper Permian lowest occurrence for *Lystrosaurus*, but all *Lystrosaurus* specimens that we can precisely locate fall above the Permo-Triassic boundary. The high abundance of *Lystrosaurus* in the Early Triassic of Xinjiang likely parallels an Early Triassic age for the interval of greatest *Lystrosaurus* abundance in the Karoo Basin, but additional research is needed to determine whether there was a single, globally synchronous time of highest *Lystrosaurus* abundance.

Funding Sources NSF EAR-1714829, NSF EAR-1713787, NSF EAR-1714749, CAS XDB26000000

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

A RECONSTRUCTION OF LATE TRIASSIC ASSEMBLAGES AND THEIR RESPONSE TO THE ADAMANIAN-REVUELTIAN FAUNAL TURNOVER

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Exposures of the Late Triassic Chinle Formation in western North America are well-known for the preservation of prehistoric vertebrate material. One of the most diverse of these vertebrate assemblages lies within Petrified Forest National Park in Arizona, and contains a variety of lobe-finned and ray-finned fishes, freshwater sharks, metoposaurs, phytosaurs, aetosaurs, crocodylomorphs, raiosuchians, early theropods, and other tetrapods. At Petrified Forest the Chinle Formation is separated into the Lower Petrified Forest Member (Adamanian) and the Upper Petrified Forest Member

(Revueltian) by the occurrence of a persistent red silcrete. Previous studies have suggested this silcrete marks a major faunal and floral turnover, potentially linked to climate change, carbon cycle perturbation, and/or shifts in tectonic regime. Sedimentological data further indicates that environmental changes within the local ecosystem may have affected taxa differently, with some vertebrate species occurring in both the Adamanian and Revueltian while others are restricted to their respective members. Changes in vertebrate faunal structure can be used to examine how a combination of shifting environmental conditions and biotic stressors may have impacted the Petrified Forest assemblage across this turnover. Previous community reconstructions within both members were focused on the balance of ‘aquatic’ and ‘terrestrial’ components of the fauna and based primarily on inferred trophic levels. Here we refine the reconstruction of vertebrate faunas within both the Adamanian and Revueltian at Petrified Forest using PAIRS analysis and NMDS ordination to identify patterns of taxon co-occurrence and similarity in faunal structure. Preliminary results indicate a surprising degree of uniformity amongst Adamanian faunas, potentially indicating taphonomic homogenization of the assemblage. This will be tested using taphonomic data collected in the field during the summer 2022 and fall 2022 seasons. Alternatively, if not taphonomically driven, the co-occurrence of many closely related genera (e.g. among the phytosaurs) would be ecologically surprising, potentially suggesting partitioning within the same habitat.

Funding Sources University of New Mexico Museum Research Traineeship Program

Technical Session 1: Dinosaurs (Wednesday, November 2, 2022, 8:00 AM)

A NEW MAASTRICHTIAN-AGED DINOSAUR LOCALITY IN THE SUSTUT BASIN OF SPATSIZI PLATEAU WILDERNESS PROVINCIAL PARK, NORTHERN BRITISH COLUMBIA, CANADA

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The Sustut Basin covers 9000 km² of north-central British Columbia, Canada, and preserves over 2000 m of Barremian to Paleocene terrestrial sedimentary rocks. Most of these occur in remote wilderness areas inaccessible by road, and as such have remained largely unexplored palaeontologically. The leptoceratopsid dinosaur *Ferrisaurus sustutensis* and the nanhsiungchelyid turtle *Basilemys* sp. are known from a single site in the Tango Creek Formation along the Sustut River in the southern portion of the Sustut Basin, with a range of plant macrofossils also recovered from nearby outcrops. Recently, fieldwork within Spatsizi Plateau Wilderness Provincial Park has yielded material from two new sites. These include an

isolated tyrannosaur tooth and indeterminate bone fragments, along with abundant fossil wood and rare fossil leaves, from one site, and as-yet-unidentified large ornithischian ribs and limb elements, a possible small theropod limb shaft, and a possible crocodylian jaw fragment, from a second more promising site.

The Spatsizi Plateau localities are higher in section than the Sustut River sites, and outcrop lithologies are consistent with those described for the Brothers Peak Formation. Palynomorphs from the *Ferrisaurus* holotype locality include the marker taxon *Pseudoaquilapollenites bertillonites*, placing the site at ~68.2-67.2 Ma and equivalent to the lower Hell Creek Formation in Montana. The Brothers Peak Formation sites on the Spatsizi Plateau are most likely between 68-66 Ma, but faulting and/or diachronous sedimentation in the basin may influence this interpretation, and additional palynological data are needed. The current high latitude position of the Sustut Basin is the result of north-south displacement of the geological terranes that make up much of British Columbia, and at deposition would have been roughly latitudinally equivalent to deposits from southern Alberta or Montana. The Sustut Basin preserves an intermontane basin bounded by rising mountains to the east and west, contrasting with the coastal floodplains from which the vast majority of Campanian-Maastrichtian Laramidian dinosaur specimens have been discovered. The similar depositional age of the Sustut Basin field localities compared to the Hell Creek Formation provides an opportunity to test hypotheses about dinosaur diversity dynamics in the lead-up to the K-Pg extinction in a previously undocumented palaeoenvironmental setting.

Funding Sources Natural Sciences and Engineering Research Council of Canada, BC Parks

Technical Session 14: Squamates & Turtles (Friday, November 4, 2022, 1:45 PM)

WHAT DOES IT MEAN TO BE A GAPE-LIMITED SNAKE, AND CAN WE IDENTIFY ONE IN THE FOSSIL RECORD?

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Establishing the feeding ecology of fossil alethinophidians is a task hindered by multiple factors: a fossil record lacking diagnostic cranial material, difficulty in calculating ancestral state reconstructions due to a lack of phylogenetic consensus between morphological and molecular data, and a limited understanding of functional morphology within extant taxa. The cranial morphology of the gape-limited basally situated alethinophidians *Anilius scytale* and *Cylindrophis* have been alternately considered as representative of the ancestral alethinophidian condition, or as secondarily adapted for small-

gaped feeding from a wide-gaped ancestor.

In more derived alethinophidians, (Colubroidea) there are multiple independent examples of gape-limited taxa arising from a wide-gaped ancestor. Using these colubroid taxa we test whether modifying the skull from that of a wide-gaped ancestor to a small-gaped feeder leaves a distinct morphological signal across cranial skeletal anatomy and cranial muscle architecture in a morphodynamic context. Using microCT and DiceCT techniques to examine the musculoskeletal system of the alethinophidian snake skull, combined with geometric morphometric analysis and the use of ternary plots, our results produce an inconsistent signal across Colubroid taxa, both between and within major clades. Our results suggest there are multiple morphological avenues which facilitate the production of a gaped-limited snake, and that the size and location of soft tissue systems can greatly alter the functional resultant movement of skeletal elements. We recommend caution to those aiming to describe the functional morphology and thus extrapolate the feeding ecology of fossil taxa, due to the high level of morphological disparity seen within our sample of Colubroids.

Funding Sources YIBS Small Grants Doctoral Pilot Grant awarded to REA

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

**ONTOGENY OF A NEW SHUVOSAURID
(ARCHOSAURIA: PARACROCODYLORMORPHA)
FROM THE UPPER TRIASSIC CHINLE FORMATION
OF PETRIFIED FOREST NATIONAL PARK**

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Shuvosauridae is a clade of bipedal, edentulous pseudosuchians which lived during the Late Triassic. Shuvosaurids are phylogenetically positioned firmly within Suchia and basal to Crocodylomorpha, opportune for investigating plesiomorphic patterns of growth within the Pseudosuchia. A unique opportunity to study the ontogeny of shuvosaurids is the Kaye Quarry: a multitaxic bonebed with a dense accumulation of shuvosaurid bones in the Sonsela Member of the Upper Triassic Chinle Formation of Petrified Forest National Park, Arizona. The material from this site likely represents a new taxon of Shuvosauridae. Eight femora, two complete and six partials were selected for thin sectioning and observation with transmitted light microscopy.

The size range is a total of 60 percent increase in size, with an estimated range of femoral length of 8–21 centimeters. One small femur (estimated 8 cm femoral length) is characterized

by an inner cortex dominated by secondary osteons, with areas of disorganized primary tissue persisting between multiple generations of secondary remodeling. The outer cortex is dominated by disorganized, primary osteons with a single concentric growth mark. The medullary cavity is bound by highly organized endosteal bone, it is unclear when during ontogeny this developed. There are indentations for vascular canals on the subperiosteal edge, which have not yet been incorporated into the cortex. The larger femur, 12 cm in length, is composed of disorganized primary osteons in the inner cortex that grades to an organized outer cortex of longitudinal canals in plexiform and lamellar bone. In the middle cortex, an annulus of parallel-fibered bone and scarce vascular canals is present on two sides of the cortex but is discontinuous around the cross-section. We interpret the discontinuous growth mark as a modulation in bone deposition coincident with the functional demands of the developing fourth trochanter.

A distribution of mostly histologically immature individuals and only a few individuals with many cessations of growth fits the hypothesis that this site contains mostly individuals that were likely ontogenetically mature. Comparisons to *Poposaurus* suggest that Late Triassic paracrocodylomorphs grew to large body sizes with cyclical and zonal bone growth, although shuvosaurids showed more parallel-fibered bone and thus likely grew at a slower rate than *Poposaurus*.

Technical Session 9: Mammals (Friday, November 4, 2022, 8:00 AM)

NEW POSTCRANIAL MATERIAL OF *ANTIACODON PYGMAEUS* (MAMMALIA, ARTIODACTYLA) FROM THE MIDDLE EOCENE OF WYOMING, AND A PHYLOGENETIC ANALYSIS OF NORTH AMERICAN DICHOBUNOID ARTIODACTYLS

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Minor Outlying Islands
Mammals experienced considerable taxonomic turnover in the Eocene, with the forebears of many modern orders replacing more archaic groups that had dominated the landscape in the Paleocene. The “Homacodontidae” represent a North American branch of the basal artiodactyls “Dichobunoidea” and are characterized by incipient selenodont dentition. The lack of described postcranial material for most members of “Homacodontidae” has limited our understanding of the evolution of specialized locomotion, a hallmark of artiodactyl evolution, along with the phylogenetic relationships of the clade. Further, most phylogenetic studies on artiodactyls have focused on the relationships of extant taxa rather than extinct basal taxa. Here I describe a specimen (UWBM 120043), attributed to the homacodontid *Antiacodon pygmaeus* from the lower Bridger Formation (Bridgerian North American Land Mammal Age) of Wyoming. This material is the most complete specimen of the species to date, and it includes an articulated left hindlimb and right forelimb. Numerous

elements of the specimen were not found in previously described specimens, namely the humerus, radius, ulna, metapodials, and lower incisors. The forelimbs share several characteristics with other previously described dichobunoids, including smaller size compared to the hind limbs, an unfused carpus, an unfused radius and ulna, and five digits. The lower incisors are spatulate, and the lower canine is incisiform, and these traits are shared with related taxa such as *Dichobune* or *Gujaratia*. Utilizing newly scored characters, I performed a phylogenetic analysis using an updated morphological character matrix that includes 89 taxa and 287 characters. Consistent with previously published phylogenetic analyses, I recovered a paraphyletic “Dichobunoidea” and “Homacodontidae”, with *Antiacodon* near the base of Artiodactyla, sister to a clade that includes Tylopoda. Thus, the new specimen fills a gap in our understanding of dichobunoid postcranial anatomy, and my phylogenetic results strengthen previous hypotheses on the relationships of early artiodactyls.

Technical Session 8: Evolutionary Developmental Biology
(Thursday, November 3, 2022, 1:45 PM)

STUDYING THE PATTERNS OF CHEEK TOOTH SHAPE COVARIATION TO BETTER UNDERSTAND THE EVOLUTION OF MOLARIZATION IN HOOFED MAMMALS

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Dental variation that exists at various taxonomic ranks has been used to differentiate mammalian taxa. The cheek teeth (premolars and molars) show a spectrum of molarization among mammalian taxa. Premolars in some taxa take on a complex molariform morphology compared to a simple unicusped morphology in others. Developmental literature has described key gene families and morphogens thought to pattern dental morphology during development in mammals. Enamel knots are signalling centers that play a primary role in modulating these gene families through morphogenetic gradients. These findings are important in understanding evolution of vertebrate dentition. However, these studies are unable to confidently identify macroevolutionary mechanisms contributing to mammalian dental diversity because they rely on extant taxa. This excludes dental morphology found in the fossil record making it difficult to understand the evolution of molarization through time. An approach with a synthetic understanding of dental development, the fossil record, and mammalian evolution could be used to highlight key areas of shape covariation. In the context of molarization, cross boundary covariation could help us uncover if certain parts of premolar shape are more influenced by molar development than others. We hypothesized that influence from important molar developmental modules may influence cusp shape formation in the premolars. We evaluated this by testing if shape covariation exists between the fourth premolar and first

molar. We captured premolar molar boundary cusp shape using geometric morphometric methods among ungulate families to use in modularity analyses. Morphometric analysis shows changes in cheek tooth morphology that could be interpreted as various modes of molarization along primary axes of shape variation – similar modes of molarization were found in modularity analyses. Artiodactyl molar shape covaries most with anterior premolar cusps while perissodactyls show the premolar and molar as mostly independent modules. Further investigation into cusp shape covariance across the boundary may elucidate developmental mechanisms contributing to the evolution of molarization and how it differs between mammalian taxa.

Funding Sources NSERC CGS-M Scholarship and NSERC Discovery Grant via DR. Jessica Theodor

Virtual Posters

WHAT DO YOU MEME? INVESTIGATING THE USE OF MEMES AS A LEARNING TOOL IN ZOOLOGY COURSES

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“Memes” as a term was coined to function as a societal gene – a fad or phenomenon that is maintained or evolves as society develops. Recently, the term meme has been used to describe popular videos, images, and gifs that capture popular media and can be used in different contexts yet retain the original meaning. We decided that using memes as a medium may help students contextualize their learning within their own frame of reference. We designed an assignment that encouraged students to generate five memes over the period of a semester in two introductory zoology courses (Invertebrate and Vertebrate Zoology). 150 students were enrolled across the two courses, 94 of which contributed to producing a total of 342 memes. With students' permission, we shared 309 memes through the class twitter account (@ucalgaryzoology). To quantify the benefit of this assignment, we administered a pre and post semester survey about using memes as an educational tool to better understand student attitudes towards using memes to demonstrate knowledge. Results in both courses show that students' attitudes towards memes are generally positive at the start of the semester and become more positive by the end of the semester. While literature is limited around using memes as a tool for learning in higher education, our study alongside other recent investigations suggest that memes are a viable way to allow students to demonstrate what they have learned in zoology courses. We propose future work to explore memes in other courses and contexts, and future conversations with students about their experiences. This work has received ethics approval by the Conjoint Faculties Research Ethics Board at the University of Calgary.

Funding Sources NSERC Discovery Grant via DR. Jessica Theodor

Technical Session 8: Evolutionary Developmental Biology
(Thursday, November 3, 2022, 1:45 PM)

DENTAL DEVELOPMENT, INHIBITORY CASCADE, AND FIRST PREMOLAR HOMOLOGY IN PLACENTAL MAMMALS

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Macroscelidid afrotherians and canid carnivorans possess four premolar loci, the first of which is not replaced. Previous work suggests that the first premolar in macroscelidids is a retained deciduous tooth, but in *Canis* it is a successional tooth with no milk precursor. We tested this contrasting interpretation of first premolar homology with data from ontogenetic anatomy and with area predictions from the inhibitory cascade (IC) model. Our results based on anatomy support previous interpretations that the functional first premolar is a retained deciduous tooth (dp1) with no successor in macroscelidids, and a successional tooth (p1) with no precursor in *Canis*. Hyracoids are among the few placental mammals that show replacement at the first premolar locus and show less deviation than other taxa of actual from predicted areas across the deciduous and molar tooththrow. However, predicted vs. actual tooth areas can depart substantially from one another. At least without a better means of representing tooth size, the inhibitory cascade does not help to distinguish the deciduous from successional first premolar. This observation does not rule out the possibility that factors such as a size-shift within the tooththrow (e.g., carnivoran carnassials) help to explain deviations from the inhibitory cascade model.

Technical Session 8: Evolutionary Developmental Biology
(Thursday, November 3, 2022, 1:45 PM)

THE EVOLUTION OF THE SKULL-NECK BOUNDARY: INSIGHTS FROM EXTANT LISSAMPHIBIANS

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The fossil record reveals a long history of morphological transformations throughout evolutionary time. Although these morphological transformations are captured in the fossil record, the developmental mechanisms underlying such

transformations are less understood. Studying the underlying developmental mechanisms requires an integrative approach combining developmental and palaeontological data. This approach has been fruitful in interpreting large scale evolutionary patterns. Unfortunately, the developmental mechanisms that drove many key morphological transformations, such as the apparent shift in the location of the skull-neck boundary, are not well understood.

Developmental work completed in the twentieth century revealed that both amphibians and amniotes incorporate more somites, mesodermal building blocks of embryos, into the head than living agnathans, and it was thought that amphibians represented an intermediate condition between the two. More recent work synthesizing palaeontological, phylogenetic, and developmental data has clarified that the extant amphibian condition is instead a secondarily derived reduction from an ancestral condition that was likely more amniote-like. This derived condition has been hypothesized to be the product of an anterior shift in the location of the skull-neck boundary along the anterior-posterior axis relative to their fossil ancestors and other tetrapod lineages. Here, we aim to further understand the potential evolutionary mechanism that gave rise to the derived lissamphibian condition via the manipulation of *Hox* gene expression domains in amphibian model organisms *Ambystoma mexicanum* and *Xenopus laevis*. We applied exogenous retinoic acid and a retinoic acid inhibitor to embryos, which resulted in the translocation of the skull-neck boundary anteriorly and posteriorly, respectively. We demonstrated that homeotic transformations occurred via three methods of evaluation, the relative location of the hypoglossal nerve complex (cranial nerve twelve) to skeletal structures, cell-lineage tracing methods, and *in situ* hybridization to visualize *Hox* genes. Significantly, anatomical details of the resulting phenotypes mimic skull-neck boundary morphologies observed in other tetrapod groups, including superficially resembling ancestral morphologies. This work suggests homeotic transformations and correlated genetic modifications may have played a role in the evolution of several aspects of the lissamphibian skull form.

Funding Sources Natural Sciences and Engineering Research Council of Canada, Ontario Graduate Scholarships Program

Virtual Posters

A NOASAURID THEROPOD FROM EASTERN AMAZONIA SHEDS LIGHT ON THE EVOLUTION OF THE PNEUMATICITY IN ABELISAUROIDS

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Noasaurids from across Brazil provide information to fill in the gap both in space and time to understand the evolution and diversification of Ceratosaurians. Here we describe the microtomography of LPP-PV-0044, a dorsal vertebra from the Cenomanian Alcântara Formation (Maranhão, Brazil). It provides insights into the evolution of the pneumatization architecture of the noasaurid axial skeleton halfway through the Cretaceous. There are only a few noasaurid vertebrae scans published and direct comparison has its limitations. LPP-PV-0044 presents camellate and polycamerate architecture. Nonetheless, the thin cloud of camellae in LPP-PV-0044 presents several centripetal layers of tiny bone walls near the cotyles, a feature not yet described in ceratosaurians but present in some titanosaurs. This raises the question that maybe this delicate tissue type allowed the convergence of this structure between two distant saurischian clades. Finally, our CT data also reveal several foramina connecting the neural canal to the camellate structures. This is described for the first time in non-avian theropods. It has only been found in two sauropods. It is another example of convergence between these two highly-pneumatized clades. The internal pneumatic architecture in presacral vertebrae varies to an extreme degree in noasaurids. *Vespersaurus*, DGM 929-R, and MNM TIG6 show a camerate pattern, while *Masiakasaurus* and NMV P252004 present a camellate pattern. *Elaphrosaurus* show a unique combination of solid apneumatic and camellae. *Noasaurus*, *Limusaurus*, as well as LPP-PV-0044 and FSAC-KK-5016 show a combination of camellate and camerate trabeculae. Our multivariate analysis found no correlation between the pneumatic tissue and systematics within noasaurids. Therefore, character 96 (Carrano and Sampson 2008) is not a good trait for differentiating noasaurid subgroups. One point that adds distortion to this character is the subjectiveness of classifying the small chambers as either camerae or camellae. The Australian elaphrosaurine NMV P252004, for example, was coded as camellate when its CT scan data show traces of both polycamerate and camellate tissue. Another point is that traces of pneumaticity are highly variable among saurischians and factors like ontogeny, axial series variation, and intraspecific diversity. Understanding the impacts of such variation in our current knowledge of dinosaur systematics remains one of the frontiers in vertebrate paleontology.

Technical Session 1: Dinosaurs (Wednesday, November 2, 2022, 8:00 AM)

A NEW ORODROMINE FROM THE MUSSENTUCHIT MEMBER OF THE CEDAR MOUNTAIN FORMATION, UTAH

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Orodrominae is a diverse clade of bipedal, small-bodied, early-diverging ornithischians, some of which are hypothesized to be fossorial. Recent phylogenetic analyses recover up to six members spanning the mid-Cretaceous of North America and Asia. Their relationships with other early-diverging ornithischians remain poorly understood. Resolving these issues is greatly facilitated by the comprehensive evaluation of new materials.

The Cenomanian-aged (98-96 Myr) Mussentuchit Member of Utah's Cedar Mountain Formation has produced a rich record for a new orodromine, including several nearly complete sub-adults and fragmentary juvenile remains from five localities. Gross anatomical comparisons and morphometric analysis of scapulae reveal it to be most similar to *Oryctodromeus* from the coeval Blackleaf and Wayan Formations of Montana and Idaho.

Synapomorphies with *Oryctodromeus* include a medial tuberosity on the scapula, an acromion process that is craniodorsally inflected (~105°) from the craniodorsal margin, a non-flaring scapular blade with the distal margin between the superior and inferior angle running in parallel with the ventral margin of the scapula, and a subtle ridge on the caudal surface of the paroccipital process. The Mussentuchit orodromine differs from *Oryctodromeus*, in lacking the sharp and ventrally folded scapular spine, but possessing a dorsoventrally elongate fossa on the medial surface of the occipital condyle located directly caudal to the medial opening of CN XII, and a rostrocaudally oriented ventral canal on the prootic. The latter two traits are absent in *Orodromeus*, *Oryctodromeus*, and *Thescelosaurus*. Dentary teeth show a unique vertical wear facet on the labial surface that terminates abruptly near the crown base. A parietal sagittal crest is absent, a condition only shared by *Lesothosaurus* and *Changmiania*. Extensive intraspecific variation is present among ischia with inflated shafts immediately distal to the obturator process and pneumaticity of sacral vertebrae.

This new orodromine represents another example of the faunal differences between the Blackleaf/Wayan and the Mussentuchit, which have been attributed to the Mussentuchit representing a coastal lowland and the Blackleaf a more upland environment. This new orodromine adds to the list of distinct but closely related lineages between the two environments, providing insights into patterns of habitat choice by different dinosaur clades.

Funding Sources The Jurassic Foundation, Paleontological Society, Canyonlands Natural History Association, and the National Science Foundation under Grant Nos. FRES 1925973 & 1925884.

Technical Session 2: Paleoecology (Wednesday, November 2, 2022, 8:00 AM)

DIFFERENT MACROECOLOGICAL HISTORIES FOR SMALL AND LARGE MAMMALS IN THE MIOCENE SIWALIK RECORD OF PAKISTAN

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The Siwalik record of Pakistan documents ~20 million years of fossiliferous sediments in a foreland basin that lies between the Asian and Indian tectonic plates. We evaluated changes in the taxonomic and ecological diversity of mammals in relation to global to local environmental changes between 18 and 6 Ma, using a database of more than 1000 fossil localities and 50,000 vertebrate specimens. Although the productivity of fossils varies notably over time, the taphonomic regime is consistent across four formations and 12 million years, suggesting that environmental and biogeographic factors exerted a greater influence on species richness than preservation rate. We analyzed species richness, per-capita origination and extinction rates, and faunal turnover for estimated first and last occurrences, based on the average temporal gap size in the stratigraphic duration of each lineage. We evaluated small mammals (<1 kg estimated adult body weight) separately from large mammals (1 kg to >1000 kg) because of major differences in collecting methods and in life-history and ecology. Small mammals consist predominantly of rodents and insectivores; large mammals include a wide range of ungulates, carnivores, and proboscideans.

Small mammals and large mammals show similarly low richness during the warm Middle Miocene, then rapidly increase, mainly via immigration, during the cooling interval at ~14.5 Ma. Thereafter large-mammal richness substantially exceeded small-mammal richness through well-sampled intervals. Diversification dynamics differ with slower rates of turnover in taxonomic composition and ecological structure for small mammals than large mammals. Peak richness (>60 species per interval) of large mammals coincided with the greatest range of $\delta^{13}\text{C}$ values in soil carbonates and herbivore teeth in the sequence; by then, small-mammal richness was on the decline.

The similarities in these histories reflect global to regional influences (feasibility of dispersal, climate change) on origination and extinction rates. The differences reflect ecological processes (productivity, seasonality, species interactions) within the bioprovince and alluvial ecosystem. Differences also suggest that small mammals are sensitive to subtle changes in food and habitat resources that anticipate major ecosystem changes well before those affect populations of larger species.

Funding Sources Smithsonian Foreign Currency Program, the National Science Foundation, and our own universities.

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

PRELIMINARY REPORT ON RECENT FINDS FROM THE CENOMANIAN CANDELEROS FORMATION OF NORTHWESTERN PATAGONIA, ARGENTINA, AND THEIR BEARING ON THE EVOLUTION OF PIPIMORPH FROGS (ANURA, XENOANURA)

Baez, Ana M.

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In the last three decades, the red beds of the Candeleros Formation, basal unit of the Neuquén Group deposited in the foreland basin of the Neuquén Basin, have yielded partially articulated and isolated, threedimensionally preserved remains of pipimorph xenoanuran frogs (aquatic crown-group Pipidae and taxa more closely related to them than to its sister-group, the fossorial Rhynophryinae), apart from an outstanding diversity of other vertebrate body fossils and tracks. The previously known pipimorph remains from the Candeleros sequence are from at least two stratigraphic levels of the mid-upper section in outcrops on the shores of the Ezequiel Ramos Mexia Lake, whereas pleurodiran and anuran materials were collected recently from the upper third of the sequence in a new site located in the Cañadón de las Campanas, 18 km northwest of the town Villa El Chocón, Neuquén province. Several postmetamorphic stages, including adults, are represented among the latter. Comparisons with the holotype of *Avitabatrachus uliana* previously described from the Candeleros sequence suggest that the remains might be referred to this taxon. Salient adult features include the well-ossified, azygous frontoparietal lacking parasagittal crests and pineal foramen and the proportionally large, quadrangular otic capsules lacking an obvious crista parotica and dorsal transverse crest. Ventrally, the otic capsule lacks a well-defined Eustachian canal although a narrow trench is formed anterior to the protuberant inner ear region, resembling the condition in juveniles of some crown-group taxa. The fenestra ovalis was located at the anterolateral margin of the otic capsule. Presacral vertebrae have dorsoventrally flat, opisthocoelous centra and extensive neural arch pedicels that in the posterior presacrals developed accessory articulations between contiguous elements. Some features, such as the anteriorly arched transverse processes on posterior presacrals, incomplete synostotic fusion of sacrum and urostyle, and crestless iliac shaft, also occur in Aptian taxa from northeastern Brazil and Israel, part of the African-Arabian Plate at that time, but are not present in adult extant members of the crown group, restricted today to South America and Africa. These features are tentatively considered plesiomorphies for pipimorphs, although the diversity in oldest records points to a still largely unknown evolutionary history.

HOW DID WHITE-TAILED DEER RESPOND TO THE PLEISTOCENE-HOLOCENE TRANSITION?

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Previous studies have demonstrated complex responses by mammals that survived the end of the Pleistocene, a time of dramatic change in climate and the extinction of the megafauna. Some species got larger in the Holocene, others got smaller, and some got larger in the early or middle Holocene, and then returned to Pleistocene size ranges in the last few centuries. Purdue (1989) suggested that astragali of white-tailed deer (*Odocoileus virginianus*) from Illinois got larger about 3,000 years ago, and remained consistently larger than early Holocene deer. We examined samples of white-tailed deer from the late Pleistocene Rancho La Brea tar pits, and compared them to specimens from modern samples in the western United States. Overall body size (as measured by their teeth) was not significantly different, but Pleistocene deer had significantly longer limbs than do modern deer. Comparisons of their astragali with the data from Purdue (1989) suggest that late Pleistocene deer astragali were smaller than those of the Holocene.

Technical Session 16: Hoofed Mammals (Saturday, November 5, 2022, 8:00 AM)

NEW SKULLS AND CRANIAL ENDOCASTS OF FOSSIL CAMELIDS SUGGEST GREAT BRAIN COMPLEXITY DURING THE PLEISTOCENE

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Artiodactyla have some of the most complex brains of all living taxa, particularly as quantified by neocortical gyrification which has reached exceptional levels in cetacean members of this group, ranking second only to those of primates. Fossil cranial endocasts have revealed patterns of deep-time brain evolution for many lineages, which are critical

to the understanding of brain form diversity today. For Camelidae, fossilized “brains” have been known from the Eocene to approximately ~10-11Mya, followed by a void in this fossil record which here we fill with the first descriptions of endocranial casts of two Pleistocene camelid taxa: a newly-discovered *Palaeolama* sp. (~1.2 Mya) from the Roth Collection at the University of Zurich (UZH), and *Camelops hesternus* (~44-11Kya). We describe and compare overall brain form but focus descriptions on the neocortical topology, placing this new Pleistocene material in the context of earlier fossil exemplars as well as living camelids. Our findings clarify several aspects of the mode and tempo of brain evolution in Camelidae, which evolved significantly between the Miocene (*Procamelus*) and through the Pleistocene. Already ~1.2 Mya ago *Palaeolama* sp. possessed features in the dorsal and parietal neocortex known previously only in extant forms. At this time, we see the first evidence of the following sulci: the intercalaire, arched sulcus, and a multi-branched ectolateral, among other changes. One million years later in the late Pleistocene (~40-11 Kya), *Camelops hesternus* had evolved a neocortical topology as complex as that in modern taxa. Revising earlier brain studies in this group, we find that the exponential increase in encephalization previously noted to have begun with *C. hesternus* appears to have started already a million years before with *Palaeolama* sp. (~1.2Mya). Given its size and neocortical topology, which is the most complex of all known fossil camelids, we suggest *C. hesternus* may have had a high capacity for information processing. We also identify neocortical characters and other brain features likely of systematic impact for Camelinae suggesting an affinity between *Camelops* and *Camelus*, to the exclusion of Lamini. This supports results from our revision of camelid phylogeny based on a parsimony analysis of 21 taxa and 49 morphological characters which places genus *Camelops* within Camelini.

Funding Sources Swiss SNF Grant no.31003A 169395, and Germaine de Stael project no.12 2021.

Education & Outreach Poster Session

FOSSIL FEVER: PALEONTOLOGY AND PARTNERSHIP IN GRASSLANDS NATIONAL PARK, SASKATCHEWAN, CANADA

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Fossil tourism is a major industry. Globally, people are drawn in their thousands to see, and sometimes to collect, fossils of charismatic animals such as dinosaurs in situ. While fossil tourism provides unparalleled opportunities for scientific outreach, increased visitation to paleontologically significant areas can lead to the unintentional damage of fossils, their illegal collection, or intentional vandalism. In Canada’s provincial and national park systems, the question of how to

balance conservation with visitor experience is foremost. Grasslands National Park (GNP) in southern Saskatchewan, Canada, protects the critically endangered native grasslands ecosystem. GNP is also home to significant fossil deposits, preserving the fossiliferous Campanian Bearpaw Formation in the park's West Block and, in the East Block, the dinosaur-rich Maastrichtian Frenchman Formation, overlying Paleocene Ravenscrag Formation, and the Cretaceous-Paleogene (K-Pg) Boundary between them. The GNP Paleontology Team was established in 2010, comprising members from Parks Canada, the Royal Saskatchewan Museum (RSM), and other outside institutions to discuss issues related to paleontology in the National Park. In partnership with the RSM, the GNP Paleo Team has developed a successful and popular public program known as 'Fossil Fever', now in its ninth year. In 'Fossil Fever', the park facilitates hands-on 'days in the field' with paleontologists excavating fossils in GNP. Program evaluations from participants of 'Fossil Fever' between 2017 and 2019 have been very positive. Increased awareness of fossil resources in the park has also resulted in knowledgeable amateurs finding and reporting more fossil sites in GNP. However, visitation to GNP has increased substantially since 2010 and, with the dramatic increase in number of people visiting the backcountry, sensitive fossil sites previously protected by their remoteness are being discovered and sometimes disturbed. The GNP Paleo Team is helping to provide more education, information, and signage about fossil collection legislation, more site monitoring, and more public awareness about the importance of leaving fossils in their original geological context. GNP provides an excellent example of how professional and amateur paleontologists, government organizations and the public can work together to help balance research, visitor experience, and protection of valuable fossil resources on protected lands.

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

THE FIRST *PROGNATHODON* SP. (SQUAMATA, MOSASAURIDAE) FROM THE BEARPAW FORMATION OF SASKATCHEWAN, CANADA, AND IMPLICATIONS FOR MARINE PALEOECOLOGY IN THE BEARPAW SEA

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The Late Cretaceous mosasaur *Prognathodon* has a global distribution, with specimens found in Campanian and Maastrichtian marine deposits in Europe, New Zealand, North America, and the Middle East. Canadian *Prognathodon* material had hitherto been reported only from Alberta. Herein is described the first partial skull and post-crania of *Prognathodon* sp. from Saskatchewan, representing the largest individual recovered in Canada to date. The specimen was discovered in 2012 near Val Marie, SK, on land that would

soon be incorporated into Grasslands National Park. The deposits here are dominated by loosely consolidated, evaporite-rich, grey marine shales of the Bearpaw Formation (ca. 75-73 Ma). A surface collection of the site by the Royal Saskatchewan Museum (RSM) in 2013 recovered several cervical vertebrae, a premaxilla, partial dentaries, teeth, ribs fragments, and paddle elements. The cranial material was sufficiently diagnostic to identify the specimen as *Prognathodon* sp., but a return to the area was not feasible for several years. In September 2021, the RSM attained a permit to excavate the site and collected two near-complete maxillae, an angular and subangular, and parts of the frontal, post-frontal, parietal, and quadrate, as well as more post-crania. Once prepared, the skull of the specimen (RSKM P3194.1) measures an estimated 130 cm in length, rendering it the largest *Prognathodon* found in Canada by a large margin. Saskatchewan has several contemporaneous endemic marine reptiles from the Bearpaw Formation, including an endemic elasmosaur (*Terminonatator ponteixensis*), polycotyloid (*Dolichorhynchops herschelensis*) and mosasaur (*Tylosaurus saskatchewanensis*). Though tentatively ascribed to *P. overtoni* based on its age and provenance, further analysis of RSKM P3194.1 may reveal it to be another endemic marine species. Paleogeographically, three other contemporaneous mosasaur species are found in Saskatchewan's Bearpaw Fm: *Mosasaurus* cf. *missouriensis*, *Plioplatycarpus* sp. and *T. saskatchewanensis*. These four large-bodied hunters shared the same shallow marine eco-space, possibly avoiding the need for discrete niche-partitioning by being generalist predators. In contrast, terrestrial ecosystems in Campanian and Maastrichtian North America supported a very limited number of large predator species. This suggests a unique ecological structure in the Bearpaw Sea at the time, with implications for understanding the eventual extinction of marine reptiles.

Virtual Posters

A REAPPRAISAL OF TITANOSAUR CLADISTIC ANALYSIS

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Titanosauria is one of the most diverse and widespread dinosaur lineages. Although the study of the systematic of this clade has grown enormously in recent years, most of the cladistic analyzes do not include the diversity of species, which exceed 50 valid genera. The main dataset known to date show at most twelve titanosaur species. Thus, the interrelationships of this important group are far from being well-understood. Recent studies have focused on resolution of cladistic instability based primarily on exclusion of unstable taxa. Other cladistic approaches are scripts searching clades with higher support. We conduct a species-level phylogenetic analysis of 571 morphological characters (23 new) and 191 sauropod taxa (115 titanosaurs) and analyzed this dataset using equally weighted parsimony. This analysis is more comprehensive in number of species of titanosaurs than any

other published to date. As result, even incomplete species (missing data greater than 50%) act as stable species, such as *Andesaurus* (>70%) and *Austroposeidon* (~79%). Our analysis retrieved that the interrelationships of Titanosauria are supported largely by axial and appendicular synapomorphies. Among the clades present in the literature, the following were recovered: Colossosauria (with Lognkosauria and Rinconsauria well-stablished); Saltasaurinae, and Aeolosaurini. Lithostrotia is supported by three synapomorphies and was recovered outside Eutitanosauria as in previous analysis. Our cladistic analysis indicated that Lirainosaurinae and Diamantinasauria as paraphyletic. In addition, seven new clades were found, one being composed of three species exclusively from the same geological context (south-west Bauru Group). An undescribed European species was recovered as the sister species of the Asian titanosaur *Hamititan*. The close affinity of these taxa suggests at least one episode of an Asian incursion into Europe despite the strong evolutionary link between titanosaur species from South America-Africa-Europe landmasses.

Funding Sources PROATEC/DEPESQ/UERJ and FAPERJ (#E-26/201.095/2022)

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

A NEW SPECIMEN OF TAPEJARA FROM THE LOWER CRETACEOUS OF THE ROMUALDO FORMATION (ARARIPE BASIN, BRAZIL) REVEALS KEY INFORMATION ON MORPHOLOGICAL VARIATION IN CRANIAL CRESTS OF TAPEJARINE PTEROSAURS

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Tapejara wellnhoferi is a well-known edentulous pterosaur species from the Lower Cretaceous Romualdo Formation (Araripe Basin, NE Brazil) characterized by short skulls, and a high-to-median premaxillary sagittal crest that covers the rostral portion of the skull. Even though it was previously published that five skulls were referred to *T. wellnhoferi*, the preservation of the premaxillary sagittal crest was limited and incomplete. Here we present a new specimen belonging to *Tapejara wellnhoferi* housed at the Museu de Paleontologia Plácido Cidade Nuvens (Santana do Cariri, Ceará), which consists of a complete premaxillary sagittal crest with a rostrum, nasal process, and most of the anterior part of the nasoantorbital fenestra. Even though *T. wellnhoferi* is the one tapejarine species from the Romualdo Formation, the distinctive crescent shape of the premaxillary crest in the new

specimens underlines the importance of more complete specimens, consequently, a comparison of cranial crests within different species of Tapejarine from the Araripe Basin was carried out through a linear morphometric analysis in order to distinguish and compare the form and shape of those specimens. Angle measurements were used to demonstrate the inclination of the anterior part of the rostrum (A1), the inclination of the anterior margin of the sagittal crest (A2), and the inclination of the maxilla (A3). Other measurements include the maximum crest height (M3) and premaxilla length (M5). All *Tupandactylus imperator* specimens have the smallest lengths in M3 and M5, but A1 shows a greater inclination of the sagittal crest anterior margin among all specimens. In contrast, *Tupandactylus navigans* show the highest result in M3 and remains with the highest result in A3, having the highest sagittal crest among tapejarines. *T. wellnhoferi* shows a morphological differentiation between the A1, A3, and M3 angulations. The comparisons between length, height, and premaxillary sagittal crest inclination among *T. navigans*, *T. imperator*, and *T. wellnhoferi* show a great variation in the latter, indicating that the shape of the crest has changed during ontogeny. Also, we do not discard the possibility of sexual dimorphism, because most of the differences between the specimens are associated with the sagittal premaxillary crest, a structure whose functions probably included sexual display. The hypothesis that sexual dimorphism in Pterosauria is associated with cranial crests has been proposed previously.

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Technical Session 9: Mammals (Friday, November 4, 2022, 8:00 AM)

MEGAVERTEBRATE REMAINS FROM THE PLIO-PLISTOCENE OF BANGLADESH – A NEW WINDOW INTO VERTEBRATE PALEONTOLOGY

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Bangladesh holds a rich record of fossil vertebrates and not much work has been done on them. Sporadic reports on megafauna have been published in several internal publications of the Geological Survey of Bangladesh. Additionally, a few reports were also published on the occurrences of fossil vertebrates from the Miocene Tipam sandstone in Bangladesh, the age of which remains unclear and may range from the Miocene to Pliocene. With this frame

of reference, the present work reports on an assorted collection of megavertebrates excavated from the reddish brown sand beds of the Nandigram Formation in the Bogura district of Bangladesh. The vertebrate fossils have been excavated approximately 20 m from the type section of the formation near the Nandigram village. Collections consist of numerous fossilized remains of mostly limb bones, an antler of a deer, a proboscidean molar, carapace of a turtle, and non-diagnostic reptilian vertebrae. The fossils are found as a mixed assemblage and adds to the record of fossil mammalian remains from Bangladesh. This region consists of clastic sediments that might have formed by the collision of the Indian plate with the Eurasian plate approximately 55 million years ago (controversially 35 million years ago) during the Paleogene period. The current fossil finds from Bangladesh are mostly Quaternary or may be of Plio-Pleistocene age. The fossil finds from the Nandigram Formation shows an affinity towards the Upper Siwalik fauna in India. Further research needs to be conducted on the taphonomy and provenance of these fossil finds to ascertain the age. Although several terrestrial vertebrate fossils have been excavated from the Western Himalayas in India, no terrestrial vertebrate fossils have so far been reported from the Eastern Himalayas of India. The presence of mammalian vertebrate fossils from Bangladesh is thus very important to establishing a strong stratigraphic correlation and thereby elucidating the migration patterns and evolution of fauna after the historic collision of the Indian plate with the Eurasian plate.

Technical Session 1: Dinosaurs (Wednesday, November 2, 2022, 8:00 AM)

DIVERGENT STRATEGIES FOR HIGH-FIBER HERBIVORY AMONG EARLY-DIVERGING ORNITHISCHIAN DINOSAURS

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Biologists have sought to understand the extent to which evolution is deterministic, and there has been intensive debate on how adaptation and constraint might canalize solutions to behavioral and ecological challenges. Here, we use the repeated evolution of high-fiber herbivory in ornithischian dinosaurs to investigate their adaptations to common ecological pressures and assess their degree of functional convergence. Previous biomechanical studies on ornithischian feeding function have focused primarily on deeply-nested representatives of the clade, so the initial pathways to ornithischian herbivory have been obscure. Here, we used microcomputed tomography to construct three-dimensional models of the skulls and mandibles of five early-diverging ornithischian taxa (*Lesothosaurus*, *Heterodontosaurus*,

Scelidosaurus, *Hypsilophodon*, *Psittacosaurus*), which represent the plesiomorphic conditions found within the major lineages in the clade. Cranial musculature was reconstructed for each taxon using their extant phylogenetic bracket, and each of these models was subjected to Finite Element Analysis. Comparisons between the patterns of von Mises stress generated by these analyses demonstrate that there were significant functional differences between the feeding apparatuses of the principal ornithischian subclades, revealing previously unrecognized and fundamentally distinct solutions to high-fiber herbivory. Although the mechanical performance of these skulls overlaps, this convergence is underpinned by distinct modifications to the skull and jaw adductor muscle architecture. Cerapodans increased the mechanical advantage of the jaws; heterodontosaurids expanded relative jaw adductor muscle volume; and thyreophorans compensated for plesiomorphically low performance through increased body size. These different functional pathways to herbivory likely underpinned the later success of this diverse and widespread clade. More broadly, these multiple solutions to an equivalent functional problem demonstrate that phenotypic evolution is not necessarily predictable, but results instead from the interplay of adaptation, innovation, and phylogenetic constraints.

Funding Sources Natural Environment Research Council (NE/R000077/1)

Romer Prize Session (Thursday, November 3, 2022, 8:00 AM)

THE EVOLUTION OF FELIFORM (CARNIVORA) CRANIAL SHAPE: THE FRUITFUL CHANNELING OF EXTREME ECOLOGY

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The carnivoran suborder Feliformia has historically been suggested as constrained or limited in its evolutionary history. These limitations are characterized by specialized clades with narrow ecology. However, these same clades also contain extreme ecomorphs such as sabertooth carnivores, suggesting that there may be a correlation between these patterns. I assessed predictive variables of cranial shape on 73 species of living and extinct feliform carnivoran using 3DGM techniques. These predictors included body size, diet, age of lineage and cranial integration. Results show support for a common allometric trajectory amongst most feliforms, save soft-flesh specialist felids (cats) and nimravids (false sabertooth cats). These latter clades have the highest disparity of all feliforms, even after adjusting for body size and age of lineage, but differ in the impact of allometry. Cranial integration showed no correlation to clade level disparity suggesting there is no underlying developmental constraint nor facilitator to actualized cranial shapes. Similarly, diet is overall a poor predictor of feliform cranial shape, but primarily due to a non-linear relationship. Taxa consuming

approximately 0–70% vertebrate material possess similar cranial shapes, while taxa consuming 80% or more vertebrate material express highly disparate cranial shapes. These results suggest one-to-many mapping of cranial shape on diet for most feliforms, but many solutions for hypercarnivores. In short, specialized (hypercarnivorous) clades are not constrained to narrow cranial shapes as their dentition may suggest, but instead fruitfully channeled to diverse morphotypes.

Virtual Posters

FIRST HISTOLOGICAL EVIDENCE OF A BONY ABNORMALITY FROM THE GHOST RANCH COELOPHYSIS QUARRY, NEW MEXICO: AN EXTERNALLY CRYPTIC EXOSTOSIS IN A COELOPHYSIS BAURI (DINOSAURIA: THEROPODA) TIBIA

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Paleopathological surveys of mass mortality assemblages reveal the frequency of occurrence of disease and injuries within dinosaur populations owing to large, stratigraphically constrained sample sizes. Previous work on one such assemblage, the *Coelophysis* bonebed from the Upper Triassic Chinle Formation, Ghost Ranch, New Mexico, failed to reveal any external morphological evidence of pathology among the hundreds of specimens recovered, suggesting a low incidence of disease and injury in the population. However, histological analysis may clarify the identification and diagnosis of pathologies in fossil vertebrates. Here we present the first evidence to our knowledge of a bony abnormality in *Coelophysis bauri*, serendipitously identified through routine histological analysis of a transverse midshaft thin section of an isolated right tibia, ROM 72668.

The midshaft periosteal surface is smooth, with no obvious swelling or distortion of the shaft. However, the thin section reveals the outermost cortex of the medial tibia is underlain by a 1.03-mm-thick bony callus composed of woven bone with dense, radial vasculature. This is drastically different from the woven bone with reticular canals deposited immediately prior. The distinctive package of radially vascularized bone is bounded on its inner surface by a line of arrested growth (LAG) and around both its inner and outer surfaces by thin bands of poorly vascularized parallel-fibered bone, similar to annuli. The LAG and “annuli” converge and continue around the outer cortex of the remainder of the tibia.

The lack of anomalous bone tissue in the medullary cavity, healed fracture surfaces, or rugose surface texture argue

against infection, fracture callus, or cancerous origin. Instead, the tissue resembles a previously published exostosis on a juvenile *Maiasaura* tibia thought to represent rapid growth in response to strain placed on the tibia by fracture of its articulating fibula. However, the *Maiasaura* exostosis is on the opposite side of the tibia from that of the *Coelophysis* specimen, and neither has a preserved fibula. Although histological evidence from the *Coelophysis* tibia is consistent with biomechanically induced rapid bone growth, the precise origin and nature of the altered stress regime the tibia experienced remain uncertain. Considering this evidence, the LAG and “annuli” may be better interpreted as evidence of an injury-induced growth stoppage, rather than a typical annual growth pause.

Funding Sources Oklahoma State University Center for Health Sciences
National Science Foundation Postdoctoral Research Fellowship in Biology
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Technical Session 4: Paleobiogeography (Wednesday, November 2, 2022, 1:45 PM)

NEW CONSTRAINTS ON THE TIFFANIAN-CLARKFORKIAN BOUNDARY (LATE PALEOCENE) IN SOUTHERN WYOMING

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The Tiffanian-Clarkforkian (Ti-Cf) boundary is defined biostratigraphically by the first appearance of Rodentia in North America, although other clades including Tillodontia and Coryphodontidae have been cited as appearing roughly synchronously with the first North American rodents. Biostratigraphic and phylogenetic data indicate that all three of these clades colonized North America at or near the Ti-Cf boundary by dispersing across Beringia from their Asian center of origin. Currently, the pattern of biotic turnover across the Ti-Cf boundary in North America is documented only from the vicinity of Polecat Bench in the northern Bighorn Basin, northwestern Wyoming. Outside of the Bighorn Basin, the diverse assemblage of fossil plants and mammals known from Big Multi Quarry (BMQ) in the Washakie Basin in southern Wyoming provides a uniquely detailed snapshot of an early Clarkforkian biota. However, correlating the diverse BMQ assemblage with the Ti-Cf faunas at Polecat Bench has been problematic, partly because mammalian taxa that co-occur at BMQ are used to characterize different late Tiffanian and early Clarkforkian biostratigraphic units in the Bighorn Basin.

Here we report a new early Clarkforkian fauna from the Washakie Basin that is ~14 meters below the level of BMQ.

The new fauna includes the tillodont *Azygonyx* sp., allowing it to be assigned to the Clarkforkian NALMA, although rodents have yet to be recovered. Other mammals documented from this new fauna include the oxyaenid *Dipsalodon* sp., the viverravid *Didymictis* sp., the phenacodontids *Ectocion osbornianus* and *Phenacodus* sp., the apheliscid *Apheliscus* sp., the paromomyid *Phenacolemur pagei*, the plesiadapid *Chiromyoides* sp., and a new species of carpolestid showing morphological affinities with *Carpodaptus jepseni* and *C. aulacodon*.

The pattern of biotic turnover across the Ti-Cf boundary in southern Wyoming differs in significant details from the Bighorn Basin record, suggesting geographic heterogeneity across North American ecosystems as the native biota accommodated invasive Asian clades such as rodents and tillodonts. Discovery of a stratigraphically lower Clarkforkian fauna in the Washakie Basin reveals that BMQ is not the earliest Clarkforkian fauna in the basin, but stronger geochronological constraints are required to assess possible anachronistic patterns shown by individual taxa, including biostratigraphically iconic mammals such as *Plesiadapis cookei*.

Funding Sources This research was partly supported by an REU supplement to NSF 1543684 and the David B. Jones Foundation. Fieldwork was facilitated by BLM permit PA15-WY-234.

Colbert Prize Session

WHAT IS *KALLIMODON*? REVIEWING THIS STEM SPHENODONTID WITH IMPLICATIONS FOR A NEW SPECIES

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Late Jurassic rhynchocephalians from the Kimmeridgian-Tithonian Solnhofen Archipelago, Germany, have been known for over 150 years, with seven to nine genera being currently recognized as valid. However, our understanding of the taxonomy of these animals is still hampered by the lack of proper descriptions and poor understanding of their general postcranial anatomy. Such is the case for *Kallimodon*, a genus sometimes synonymized with *Leptosaurus*. There are two recognized species of *Kallimodon*, *Kallimodon pulchellus* from the Solnhofen Archipelago, and *Kallimodon cerinensis* from the Late Kimmeridgian lithographic limestones of Cerin, France. However, the diagnoses for both species are still vague and require re-evaluation. Three specimens comprising almost complete and articulated skeletons from the Bayerische

Staatssammlung für Paläontologie und Geologie (SNSB-BSPG) are currently assigned to the species *Kallimodon pulchellus*. A re-evaluation of these specimens, using both UV-light photography and CT-scanning, as well as a new phylogenetic analysis, suggests that there are at least two different species in the collection. The specimen SNSB-BSPG 1922 I 15 is a small, and possibly not fully mature specimen, due to the lack of ossification in the olecranon of the ulna and carpals. This specimen is similar to the larger, possibly mature holotype of *Kallimodon pulchellus* (SNSB-BSPG 1837 VI 1), in having a posteriorly curved posterior margin of the parietal, a fused dentigerous plate in the palatine, and stout forelimbs with elongated digits. It differs from the holotype, however, in the presence of a prefrontal crest, a completely open ectepicondyle foramen, and a hook-shaped anterior process of the scapula. None of these features can be explained by ontogenetic differences. Our preliminary phylogenetic analysis recovers this specimen and *Kallimodon pulchellus* as stem Sphenodontidae, the clade that comprises the only extant rhynchocephalian, *Sphenodon punctatus*. A detailed description of these specimens will also allow for a proper re-evaluation of *Kallimodon*, with a revised diagnosis, and a better understanding of the early evolution and radiation of sphenodontids.

Funding Sources VB and OWMR are funded by the Deutsche Forschungsgemeinschaft (DFG) - Projekt RA 1012/28-1

Preparators' Session (Thursday, November 3, 2022, 8:00 AM)

THE USE OF SODIUM POLYTUNGSTATE TO ACCELERATE THE PICKING OF VERTEBRATE MICROFOSSILS: A CASE STUDY FROM THE ELLISDALE FOSSIL SITE

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Sodium Polytungstate (SPT) is a non-toxic salt combined with distilled water to create dense aqueous solutions (up to 3.1 g/ml) that can be used in a sink-float process to separate materials of different densities. Materials that are less dense than the solution float to the surface and denser materials sink to the bottom. The less dense material is removed from the surface. The denser material retrieved from the bottom. It is used extensively in paleontology to separate microfossils from the surrounding mineral grains and clasts.

The Ellisdale Fossil Site in New Jersey is significant for the diverse collection of Late Cretaceous vertebrate microfossils from eastern North America. In addition to the vertebrates, the site also contains significant quantities of charcoal that obscure microfossils when picking. The initial purpose for the SPT treatment of this site was to float the charcoal and sink the fossil remains to make it easier and quicker to find the fossils. After some testing, the fossils were determined to be denser than 2.75 g/ml. For reference, quartz is 2.65 g/ml.

The vertebrate microfossil material was initially wet screened with 1 mm and 0.425 mm nested sieves. After each sample dried, about 50ml of screened material were added to a 250 ml beaker filled with 100 ml SPT adjusted to 2.75 g/ml. The solution was gently stirred, filled the rest of the way with SPT, and left alone for ten minutes to let the contents settle. A small stream of SPT was then added to coax the less dense material to flow off into a collecting tray. Once the surface was clear, the contents of the beaker were poured through a 0.1 mm sieve and allowed to drain. The same was done with the fluid in the tray in another 0.1 mm sieve. Both sieves were rinsed three times with distilled water to recover the SPT. The rinsed solution was filtered to remove particles and left to evaporate. The density of the solution was checked as the water evaporated until it was at 2.75 g/ml and then poured into a storage bottle to be used again.

This process took about 4 man-hours over the course of two days to complete. It separated about 80 percent of the sample as float, leaving the last 20 percent as sink. The sink contained largely iron oxides, pyrite, glauconite, and clay aggregates. The fossils stand out among these minerals and were easily picked.

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

BONE WEATHERING UPDATE – RATES, ENVIRONMENTAL CONTROLS, AND APPLICATIONS TO THE FOSSIL RECORD

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Bone weathering stages (WS) were established in 1978 for large mammals in Amboseli National Park, Kenya. The descriptive categories (WS 0-5) were based on progressive cracking, flaking, and splitting of bones exposed on land surfaces over 15 years, and this framework has proved useful for characterizing modern and fossil assemblages. Ongoing monitoring in Amboseli plus research in other ecosystems expands taphonomic understanding of weathering rates and environmental controls. Here, we focus on cumulative bone weathering data from Amboseli (a semi-arid tropical ecosystem) and compare this with similar data from temperate (Yellowstone National Park, WY) and arctic (Arctic National Wildlife Refuge, AK) ecosystems, extending observations over five decades and across nearly 70 degrees of latitude. Patterns and rates of weathering vary because of: 1) taxon, body size, skeletal part, and ontogenetic stage, 2) early post-mortem processes (e.g., defleshing, mummification, burning), 3) micro-environment (sun vs. shade, wet vs. dry, partial burial, plant growth, soil microbes, etc.), 4) macro-environment: climate (latitude) and seasonality (freeze-thaw,

wet vs. dry), and 5) rapid permineralization. The initial hope that weathering stages could provide a “taphonomic clock” for years of surface exposure between death and burial is tempered by the effects of micro- and macro-environmental controls on bone weathering rates. When these variables are accounted for, however, bone weathering distributions in modern surface assemblages provide useful ecological information, including decade-scale changes in animal populations and unusual mortality pulses. In fossil assemblages, bone weathering potentially could provide evidence for rates of burial and degrees of time-averaging (e.g., attritional versus mass mortality). However, applying modern WS to fossil bones is challenging because weathering features (cracking, flaking, splitting) can be very similar to damage caused by other taphonomic processes before, during, and after burial as well as diagenesis and exhumation of fossils onto modern outcrop surfaces. Strategies for investigating bone weathering in the fossil record should focus on damage patterns that closely resemble those of modern weathering stages, excavated rather than surface-collected specimens, bone surfaces preserved under sediment matrix (e.g., fine cracks following bone structure), and variation of weathering features in single bone assemblages.

Funding Sources National Geographic Society (Grants 1508, 4339-90, 7525-03, 8784-10, 9757-15), National Science Foundation Grant DEB-2135479

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

RECONSIDERING THE OSTEOLOGY AND SYSTEMATICS OF THE HADROSAURID NAASHOIBITOSAURUS OSTROMI (ORNITHOPODA: DINOSAURIA) FROM THE UPPER CRETACEOUS KIRTLAND FORMATION OF NEW MEXICO

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Accurately assessing biodiversity is essential to understanding ecosystem dynamics and the evolutionary processes that constructed them. In Late Cretaceous terrestrial ecosystems, hadrosaurid dinosaurs are particularly important given their abundance, their role as primary consumers with a near-global distribution, and in investigations of biogeography and paleoecology.

The saurolophine hadrosaur *Naashoibitosaurus ostromi*—represented by a single subadult specimen (NMMNH P-16106) consisting of a nearly-complete cranium and select postcrania from the De-na-zin Member of the Kirtland

Formation, New Mexico (~73.5 Ma)—was diagnosed three decades ago based on the unique juncture between the nasals, frontals, and prefrontals. Ever since, the specimen's taxonomic identity has been contentious due to suggested synonymy with the penecontemporaneous hadrosaurid *Kritosaurus navajovius* from the same geologic member.

Further preparation of NMMNH P-16106 has revealed additional features. Preliminary analysis suggests the presence of at least two possible autapomorphic characters: 1) medially expanded wings of the prefrontal; and 2) lateral surface of the jugal flush between the rostral process and orbital constriction, with no medial bowing of the rostral process. Other key characters of *N. ostromi* include some that are seen in Kritosaurini hadrosaurs. These include: 1) overall shape of jugal in its expansive caudoventral flange; 2) flat ventral margin of the rostral process; and 3) prominent projection of the rostral apex. As in *Kritosaurus horneri* (BYU 12950, the holotype of *Anasazisaurus horneri*), the dorsal margin of the nasals is flat in lateral view, with a sharply angled peak at the apex of the crest located anterior to the orbit. *N. ostromi* also exhibits some characters found in Saurolophini: 1) posterior narial fenestra deeply notched in a narrow V-shape; 2) frontals excluded from the orbital margin; and 3) the rostrocaudal length of the dorsal margin of the orbit is ~250% the length of the infratemporal fenestra dorsal margin.

Due to its mosaic of shared and autapomorphic characters, *N. ostromi* is not yet conclusively supported as a kritosaurini nor as a distinct taxon, pending further detailed phylogenetic analysis and ontogenetic assessment. However, this new osteological information will facilitate detailed comparisons of other specimens referred to Kritosaurini that will clarify the systematics of these poorly known late Campanian hadrosaurids.

Technical Session 19: Marine Mammals (Saturday, November 5, 2022, 1:45 PM)

THE EARLY MARINE-FRESHWATER TRANSITION OF THE PLATANISTIDAE (CETACEA: ODONTOCETI) IN TROPICAL SOUTH AMERICA

Benites Palomino, Aldo M.¹, Aguirre-Fernandez, Gabriel¹, Flynn, John², De Muizon, Christian³, Ochoa, Diana⁴, Tejada-Lara, Julia⁵, Altamirano, Ali⁵, Baby, Patrice⁶, Salas-Gismondi, Rodolfo⁴

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The South Asia river dolphin (*Platanista*) and the Amazon River dolphin (*Inia*) are extant freshwater members of two distantly related clades of odontocetes (toothed cetaceans). Fossils from marine deposits across the globe indicate that both Platanistidae and Iniidae were common inhabitants of coastal ecosystems during the Miocene. Isolated earbones documented from Miocene deposits of Colombia and Peru suggest that platanistids inhabited inland ecosystems prior than iniids, yet evidence is still scarce. Two new skulls recovered from marine layers in Urumaco (Venezuela) and Pebas (Peru) enlighten the mode and timing of the marine-freshwater transition of platanistids in tropical South America. These specimens show strong similarities with *Pomatodelphis* and *Zarhachis* and suggest that middle Miocene marine incursions from the Caribbean area reaching western South America catalyzed the continental invasion of platanistids as early as the Burdigalian. A third skull found in younger, freshwater deposits of the Pebas Formation is among the largest platanistids recorded so far. A mixture of advanced and archaic features in this skull are observed in *Platanista* (e.g., presence of well-developed maxillary crests and a strong asymmetry in the area of the bony nares) and more stemward platanistoids (e.g., a dorsoventrally flattened long rostrum and enlarged supernumerary teeth). Phylogenetic analyses cluster the new forms with *Platanista* and *Pomatodelphininae*, thus indicating that the invasion of freshwater environments in South Asia and South America among coastal platanistoids was not an isolated event. These findings along with the fossil record worldwide suggest that the distribution of extant river dolphins is relictual, resulting from successive freshwater invasions throughout the Neogene.

Funding Sources 104-2018-Fondecyt and NatGeo Grant CP-035R-17 to RS-G

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

LIKE A TYRANNOSAUR IN THE PALEOCENE: DID A GORGONOPSIAN SURVIVE THE END-PERMIAN EXTINCTION?

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Gorgonopsian therapsids were the dominant terrestrial vertebrate predators of the late Permian (Lopingian), but are generally thought to have died out during the end-Permian mass extinction 252 million years ago. There is one historical published record of a gorgonopsian specimen (a partial skull) from the Early Triassic (Induan) *Lystrosaurus declivis* Assemblage Zone (LAZ) of the Karoo Basin of South Africa,

but it has largely been disregarded by subsequent workers as representing either reworking or misidentification. Restudy of this specimen indicates that it is definitely a gorgonopsian, referable to the genus *Cyonosaurus*. Furthermore, here we present two additional, newly recognized gorgonopsian specimens from exposures mapped as the LAZ. Although poorly preserved, their morphology is also consistent with identification as *Cyonosaurus*. Based on available evidence, we do not consider reworking to be a satisfactory explanation for the anomalous stratigraphic occurrence of these specimens. If reworking was occurring at any of these sites, one would expect to also find examples of the most abundant Permian taxa (e.g., *Daptocephalus*), which vastly outnumber predatory taxa. Another possibility is that these specimens were collected from Permian strata, and their recorded origins in Triassic sediments were mistaken. To address this possibility, we revisited the original sites where these specimens were collected. Two of them span the Permo-Triassic boundary, but the third locality preserves only Early Triassic strata and yields numerous fossils unique to the LAZ. Although further scrutiny of these sites is necessary, the existing data supports gorgonopsian survival into the earliest Triassic. However, the Triassic gorgonopsians are rare, small, and only of a single taxon, indicating that they were a “dead clade walking”, and that Gorgonopsia as a clade should still be considered a victim of the end-Permian mass extinction.

Funding Sources Palaeontological Scientific Trust (PAST)

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

A PATHOLOGICAL FEMUR OF AN IGUANDONTIAN DINOSAUR WITH MEDULLARY-LIKE BONE INVOLVEMENT IN THE HEALING PROCESS

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Medullary bone is an endosteal tissue usually associated with the ovulation period in birds. Recently, this tissue has been identified in non-avian dinosaurs, such as *Tyrannosaurus*, *Allosaurus*, and *Tenontosaurus*, and its presence was used to hypothesize that the affected individuals were female. However, some authors have suggested that medullary bone can also develop from other biological causes, including pathologies. Here, we describe an iguanodontian femur from the Weald Clay Formation (England) that exhibits a large overgrowth with a medullary-like tissue in the medullary cavity. The specimen was scanned with micro-computed tomography (microCT) and later sectioned for histological analysis at three separate locations of the overgrowth. The femur belongs to a subadult Iguanodontia indet. based on the

presence of secondary bone in the periosteum and three to four lines of arrested growth. The internal analysis of the dome-like abnormality enabled the identification of a traumatic healing callus. The injury occurred some months prior to the death of the individual, and it might have influenced its locomotion as the trauma impacted on the region above the knee, a crucial location for hindlimb musculature. No sign of infection or further complications post-trauma were recognised, suggesting that the animal was correctly healing. The cancellous medullary-like tissue can be clearly distinguished from the “normal” appearance of endosteal bone. The presence of such a structure might suggest the role of a calcium reservoir to repair the trauma, but future analyses are needed to better understand its role in processes unrelated to reproduction.

Technical Session 7: Paleogene Mammals & Primates & Carnivora (Thursday, November 3, 2022, 1:45 PM)

VESTIBULAR SENSITIVITY AND LOCOMOTOR BEHAVIOR IN EARLY PALEOCENE MAMMALS

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The end-Cretaceous extinction triggered the collapse of ecosystems and a drastic turnover of mammalian communities. During the Mesozoic, mammals were ecologically diverse, but less than extant species. Modern ecological richness was established by the Eocene, but questions remain about the ecology of the first wave of mammals radiating after the extinction. Postcranial fossils are often used to determine locomotor behavior; however, the semicircular canals of the inner ear also represent a reliable proxy. These canals detect the angular acceleration of the head during locomotion and transmit neuronal signals to the brain to allow stabilization of the eyes and head. Accordingly, vestibular sensitivity to rapid rotational head movements is higher in species with a larger canal radius of curvature and more orthogonal canals. We used high-resolution computed tomography scanning to obtain inner ear virtual endocasts for 30 specimens. We supplemented these with data from the literature to construct a database of 79 fossils from the Jurassic to the Eocene and 262 extant mammals. We compared data on

canal morphology and another lifestyle proxy, the size of the petrosal lobules, which have a role in maintaining eyes' movements and position.

We find that Paleocene mammals exhibited a lower average and more constricted range of Agility Indices (AI), a new measure of canal radius size relative to body size, compared to Mesozoic, Eocene and extant taxa. In the early Paleocene, body mass and canal radius increased, but the former outpaced the latter leading to an AI decline. Similarly, their petrosal lobules were relatively smaller on average compared to other temporal groups, which suggests less ability for fast movements. Additionally, Paleocene mammals had similar AIs to extant scansorial and terrestrial quadrupeds. In contrast, the lack of canal orthogonality change from the Mesozoic to the Paleocene indicates no trend toward lower vestibular sensitivity regardless of changes in body size. This result may reflect functional differences between canal orthogonality and radius size. Our results support previous work on tarsal morphology and locomotor behavior ancestral state reconstruction suggesting that ground dwelling mammals were more common than arboreal taxa during the Paleocene. Ultimately, this pattern may indicate that the collapse of forested environments immediately after extinction led to the preferential survivorship of more terrestrially adapted mammals.

Funding Sources Marie Skłodowska-Curie Actions: IF, European Research Council StG, National Science Foundation, Belgian Science Policy Office, DMNS No Walls Community Initiative.

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

INTERNAL CRANIAL ANATOMY OF LITARGOSUCHUS LEPTORHYNCHUS AND THE IMPLICATIONS FOR NON-CROCODYLIFORM CROCODYLOMORPHA

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Computed tomography imaging and digital reconstruction techniques have rapidly expanded our understanding of crocodylomorph internal cranial anatomy. Despite this, the non-crocodyliform crocodylomorph (“sphenosuchian”) condition is primarily known from a single taxon: *Almadasuchus figarii*. This later-diverging taxon possesses several classically crocodyliform features apparently absent in other “sphenosuchians”, such as quadrates fused to the braincase. To sample endocranial morphology from earlier-diverging taxa, we have digitally reconstructed CT scans of

Litargosuchus leptorhynchus, a small and gracile animal from the upper Elliot Formation of South Africa known from a single, possibly juvenile specimen (BP/1/5237). We identify numerous and unexpected differences between *L. leptorhynchus* and *A. figarii*. Unlike the tubular brain endocast of *A. figarii*, *L. leptorhynchus* possesses well-demarcated brain regions with distinct cerebral hemispheres suggestive of a close brain-to-endocast correspondence. The cerebellar portion of the endocast lacks the “posterior abrupt step” of *A. figarii* but exhibits a proportionally larger flocculus. The endosseous labyrinths of *L. leptorhynchus* are large compared to the endocast and have elongated semicircular canals. Like *A. figarii* and other crocodylomorphs, the braincase of *L. leptorhynchus* is highly pneumatized with large basioccipital and trigeminal recesses, but the quadrate diverticula have yet to significantly expand. In *L. leptorhynchus*, the dorsal venous sinus connects the brain endocast to the temporo-orbital canal, a feature absent from *A. figarii* and only currently found in thalattosuchians and dyrosaurids. Finally, *L. leptorhynchus* possesses a novel venous sinus medial to the posterior semicircular canal that projects from the brain endocast and exits the skull posteriorly. This feature is not known to exist in any other crocodylomorph taxon. Our results suggest an underappreciated diversity of internal cranial morphology in “sphenosuchians”. The enlarged flocculus and semicircular canals of *L. leptorhynchus* may indicate visual specializations and enhanced eye and head stabilization, while the close brain-to-endocast correspondence is in line with the small size and possible ontogenetic stage of the specimen. Additional “sphenosuchians” will contextualize the phylogenetic spread and ecological/developmental signals of the features identified here.

Funding Sources NSF DEB 1754596; NRF AOP 118794; and GENUS, the DSI/NRF Centre of Excellence for Palaeosciences

Technical Session 8: Evolutionary Developmental Biology (Thursday, November 3, 2022, 1:45 PM)

THE ORIGIN OF THE BIRD ROSTRUM AND KINETIC APPARATUS INVOLVED EVOLUTIONARY “STOPGAP” PHASES AND WAS LINKED DEVELOPMENTALLY TO TRANSFORMATIONS IN THE AIR PASSAGE AND JAW MUSCLES

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The bird head is transformed such that it operates not only as a mouth but also as the principal apparatus of prehension — a role it adopted as the dexterous early avialan hand was progressively incorporated into the structure that would

become the avian wing. This transformation involved a mobilization of the quadrate, a rearrangement of cranial muscles to actuate that bone, a release of lower temporal and circumorbital elements to permit movement, and a wholesale rearrangement of the palate. Simultaneously, the maxillae were dramatically reduced and the air passage widened, possibly in association with elevated metabolic needs. A sparse record of three-dimensional non-avian avialan skulls and a dearth of embryological data has obscured the evolution and the development of the avian cranial apparatus. We use new three-dimensional data from fossil deinonychosaurs, early avialans, and the more crownward avialan clades Enantiornithes and Ornithuromorpha to show that the modernization of the avian skull included several unexpected “stopgap” steps unpredictable from extant taxa alone. In particular, the peripheral maxillary air spaces first expanded and only later were coopted by the central air passage, leading to the ultimate elimination of the facial process and the flattening of the maxilla. The earliest form of the kinetic apparatus required several additional lateral joints because various cranial elements retained their plesiomorphic extents before disappearing or becoming reduced. We additionally show using new three-dimensional embryological data that the form of the rostral ossified elements follows closely the form of the cartilaginous nasal capsule and that the cranial muscles transform in part owing to very early timing differences. Moreover, paralysis and hypermobilization experiments demonstrate that formation of at least some of the cranial kinetic joints is dependent on the action of those muscles and is therefore an epiphenomenon — or epigenetic in the classical sense — instead of a direct result of molecular patterning.

Funding Sources National Science Foundation, USA

Colbert Prize Session

IS MORE DATA WORTH IT?: CREATING LIFELIKE FINITE ELEMENT MODELS FOR PALEOBIOLOGICAL STUDIES

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Finite element methods have been utilized by paleontologists for over two decades comparing inter/ intraspecific differences in bone mechanics of modern and fossil specimens. The most common current practices assign a single material property (e.g., Young’s modulus) to the model. However, these models are relatively simple and likely do not accurately portray stress and strain present in actual biological structures. With a paucity of validation testing, it is unknown how accurate most model outputs are compared to their real-life counterparts. This project aims to validate a humerus finite element model based on homogeneous, literature-based, and experimental material properties, respectively. It is hypothesized that the more site-specific material properties assigned to the model, the more accurate it will be when cross validated with

experimental data from mechanical bending tests. A domestic dog humerus (*Canis familiaris*) was CT scanned and finite element models were constructed and defined with constraints at the proximal and distal ends. An arbitrarily chosen 1,000N of force was directed downward on the mid shaft towards the anterior side of bone. The first model was run with a single material property as in current practices, the second with three material properties based on values found in the literature, and the third with 38 material properties based on new experimentally collected relative hardness data. The actual humerus specimen was tested using an electromechanical testing frame under the same boundary conditions as the model simulations. The homogeneous model recorded the highest magnitudes of tensile and compressive strain while the model with three material properties recorded the lowest. When finite element results were compared to experimental data, relative strain magnitudes along a data transect across the bone shaft were replicated in minimum principal strain, but failed to reproduce maximum principal strain. The model with a single material property, as used in current practices, was the most similar in terms of tensile strain magnitudes. These findings are consistent with what has been reported in experiments that use cross validation with skulls and further indicate more data isn’t always necessary, at least if relative strain magnitudes are the values of interest.

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

NEW TETRAPOD FOSSILS AND GEOLOGY OF THE MISSISSIPPIAN RED BED DEPOSITS NEAR GOREVILLE, SOUTHERN ILLINOIS

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Terrestrial systems of the Carboniferous period of Illinois are known mostly from the Mazon Creek, Francis Creek Shale, an Upper Carboniferous deposit of North Eastern Illinois. Little work has been conducted on terrestrial systems of the Lower Carboniferous period, mostly due to a lack of exposed fossil beds of this age. Previous work in Southern Illinois on the Kinkaid Limestone Formation, near Goreville, Illinois, located Lower Carboniferous (Mississippian: Serpukhovian), fossiliferous red bed shale deposits yielding vertebrate taxa including the early tetrapods *Proterogyrinus*, *Greererpeton*, and an unnamed species of ‘microsaur’, and the lungfish *Tranodis*. In particular, the “Goreville microsaur”, as it has been referred to in the literature, remains incompletely described but may uniquely inform contemporary debates on

the timing of the origins of Amniota, the affinities of recumbirostran “microsaurs,” and the nature of the amniote stem group.

A fairly extensive red bed occurs just below a calcareous, dark gray shale that underlies the Goreville Limestone member of the Kinkaid Limestone Formation (Serpukhovian/Chesterian). The red bed is in the upper part of the Cave Hill Shale Member of the Kinkaid. It is a widespread marker bed that represents a regression and drying period in the Illinois Basin. The red bed is composed of red and green mottled claystone but also contains deep purple and dark red layers in some locations. Tetrapod bones have been found within the red bed surrounded by a yellow-orange halo.

Although the excavation of the site primarily occurred in 1984, the material has not received thorough treatment to date. Renewed field efforts in 2021 have relocated the Lower Carboniferous Goreville fossil beds and recovered new material that allows us to establish the stratigraphic context of the locality. Here we provide a full description of the local geology, a new stratigraphic section identifying the fossil-bearing layers, and a systematic overview of known vertebrate material from the site. This includes newly-identified colosteoid specimens with diagnosable limb material attributable to *Greererpeton*. These promising results strongly suggest that continued work in the Goreville red beds will help elucidate terrestrial vertebrate diversity of the Illinois Basin during the Mississippian.

Funding Sources Illinois State Geological Survey

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

IT'S A HARD KNOCK LIFE: PATHOLOGIES AND SCAVENGING MARKS ON AN *APATOSAURUS EXCELSUS* FROM THE BASAL BRUSHY BASIN MEMBER OF THE MORRISON FORMATION (TITHONIAN, LATE JURASSIC) NEAR MOAB, UTAH

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BYU 18531 is a large individual (pelvic width 2.06 m, femur length 1.73 m) of *Apatosaurus excelsus* excavated at Mill Canyon, north of Moab, UT, USA. The remains, along with gastropods, a crocodylian dermal ossicle, and 24 shed *Allosaurus* teeth were found in a green, silty mudstone. The skeleton, preserved lying on its left side, consists of a largely articulated vertebral series in the opisthotonic death pose, along with other elements such as a scapulocoracoid, ilia, pubes, femora, a partial ischium, and cervical and dorsal ribs. Because of the completeness and the absence of distortion, the cervical series is currently being studied to determine the neck posture and range of motion.

Shortly after death, bones of the mid-axial and appendicular portions of the skeleton including the ribs were disarticulated. The pelvis is displaced and its posterior half is absent, apparently lost to scavenging. An indeterminate number of bones were lost to modern erosion and casual collection prior to excavation.

The skull and atlas were not preserved. The shaft of the left rib of the axis is severed, and the axis and C3 were encased in a large limonitic concretion and angled acutely relative to the balance of the articulated cervical series. Tooth marks are present on the ilia, the right prezygapophyses of C12 and C13, and an anterior caudal vertebra. Pathologies include pits on the condyles of vertebrae, which may be from disease, and pits and rugose bone on the right coracoid and distal end of the left fibula, possibly from injuries. Thickened and contorted growths on two of the ribs represent bones broken in life and subsequently partially healed.

The green (reduced Fe), mudstone matrix, gastropods, and the opisthotonic posture indicate burial in ponded water sufficiently deep to float at least the neck and tail in a floodplain environment. We speculate the missing skull/atlas, the sliced axis cervical rib, and the displacement of the axis and C3, indicate the head was lost to scavenging or predation. The apparent dismantling of the appendicular skeleton and mid-axial region was a function of scavenging on-site, evidenced by tooth marks on the bones and the shed *Allosaurus* teeth. All this suggests that the individual led a hard life, suffering and recovering from injuries/diseases, only to be scavenged, and perhaps killed by *Allosaurus*.

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

SEXUAL DIMORPHISM IN THE WALRUS MANDIBLE: COMPARATIVE DESCRIPTION AND GEOMETRIC MORPHOMETRICS

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The modern walrus *Odobenus rosmarus* is characterized by marked sexual dimorphism, related to its polygynous behavior and the aggressive competition between males during the breeding season. Previous studies treated skeletal sexual dimorphism in walruses either qualitatively or with basic quantitative measurements.

The present study combines a detailed qualitative comparison of male and female walrus mandibles with quantitative two-

dimensional geometric morphometrics (Principal Component Analysis, Procrustes ANOVA and a linear discriminant analysis). In addition to identifying previously recognized sexually dimorphic features (e.g. convexity of the anterior margin of the mandible in adult males), our study finds new morphological differences between males and females, such as a relative dorsal expansion of the anterior part of the mandible and an accentuated concavity between the dorsal margin and the coronoid process in adult males.

With these two techniques combined, our results demonstrate that sexual dimorphism as expressed in the mandible of extant walrus is significant and that features of mandibular morphology can be used as tools to attribute sex with a good degree of accuracy to isolated mandibles or skeletons lacking the cranium. Sexual dimorphism in walrus is directly related to their sexual behavior. Indeed, polygyny and the related aggressive sexual behaviors between walrus males necessarily impact the morphology of their skeletal elements, including the mandibles. The difference in size of the tusks between males and females but also the use of those during intraspecific fights, can reasonably account for this great mandibular morphological disparity between adult males and females but also among different ontogenetic stages. Finally, the results obtained in the present study may serve as a starting point for assessing sexual dimorphism and studying inter- and intraspecific variation in the mandibles of fossil walrus by identifying quantified size and shape mandibular features.

Technical Session 7: Paleogene Mammals & Primates & Carnivora (Thursday, November 3, 2022, 1:45 PM)

THE OLDEST HYPERCARNIVORE (PLACENTALIA, MAMMALIA, HYAENODONTA) FROM THE FAYUM DEPRESSION, EGYPT

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The Eocene-Oligocene Boundary (EOB) marks a dramatic turnover in terrestrial mammalian faunas in the Northern Hemisphere. A recent study of Afro-Arabian rodents, primates, and hyaenodonts through the Paleogene documented a similar turnover in taxonomic and morphological diversity across the EOB in Afro-Arabia. The Fayum Depression in Egypt is the only region in Afro-Arabia that documents the evolution of terrestrial mammals across the EOB, making the full description of Fayum diversity crucial for understanding this recently-recognized extinction and recovery. The oldest, most fossiliferous locality in the Fayum is called BQ-2 (late Eocene; ~37 Ma). BQ-2 serves as the “baseline” for

interpreting later changes in the Fayum terrestrial sequence. Several rodents and primates have been described from BQ-2, but the hyaenodonts have not yet been described. One small hyaenodont is attributable to the skunk-sized hyaenodont genus *Masrasector*. *Masrasector* is a small mesocarnivore found in both Eocene and Oligocene quarries in the Fayum. Here, we describe another, more unique, small hyaenodont from BQ-2. The new taxon is known from a complete upper maxilla fragment that preserves P4 through M3. The paracones and metacones are nearly fused and are buccolingually compressed; the metastyle is mesiodistally elongate and sectorial; the protocone is mesiodistally narrow; and the trigon basin is compressed, all morphology shared with hypercarnivorous mammals. Like *Masrasector*, the new BQ-2 hyaenodont is small, making it similar in size and diet to an Egyptian mongoose (*Herpestes ichneumon*). A tip-dating Bayesian phylogenetic analysis resolved the new BQ-2 hypercarnivore as part of a clade that includes *Lahimia* and *Boualitomus*, two of the oldest hyaenodonts known from Afro-Arabia. Another member of Boualitominae was found at L-41, a different late Eocene Fayum quarry (~34 Ma). Hyaenodonts were the dominant terrestrial mammalian carnivores in Afro-Arabia throughout the Paleogene. Boualitominae persisted through much of the Paleocene and the entire Eocene. However, no members of this clade have been identified in the Oligocene, suggesting this clade may be a casualty of the EOB extinction event. With the description of this new taxon, we can begin to examine how the extinction of this ancient hyaenodont clade may have opened up new ecological opportunities for later hyaenodonts, and eventually, carnivorans.

Funding Sources Data collection was partially supported by US NSF DBI 2023087, DEB-1311354, and DBI-1612062 and IMLS MA-245704-OMS-20 and ARPML-250672-OMLS-22

Virtual Posters

SOFT-TISSUE RECONSTRUCTION AND AIRFLOW THROUGH THE NASAL PASSAGES OF THE PTEROSAUR, *BARBOSANIA GRACILIROSTRIS*: IMPLICATIONS FOR RESPIRATORY PHYSIOLOGY, THERMOREGULATION, AND OLFACTION

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The medium-sized targaryendraconid pterodactyloid, *Barbosania gracilirostris*, is represented by a well-preserved, 3-dimensional skull (SMNK PAL 3895) that lends itself to the reconstruction of potential soft tissues in the enlarged nasoantorbital region of pterosaurs. Using synchrotron scan

data, we segmented the skull of *B. gracilirostris* and used anatomical landmarks found on the facial bones to reconstruct the limits of the nasal passages and their associated paranasal sinuses. The well-developed nasal process in this specimen descended along the midline of the nasal cavity and likely represents a bony support for the cartilaginous nasal septum. The nasal process provided a minimum thickness for the nasal septum, which allowed us to reconstruct physiologically reasonable limits on nasal passage size within the nasal cavity. Distance between the nasal septum and inner boundary of the antorbital sinus was a snug 21 mm, indicating an already relatively compressed nasal passage in this pterosaur. Comparisons with extant animals indicates that three-quarters of this available space was likely filled with well-vascularized mucosa. Depressions on the ventral side of the nasals suggest the presence of a well-developed olfactory recess in this species, suggesting that *Barbosania* had a fairly good sense of smell despite reduced olfactory bulbs compared to earlier pterosaurs. We used computational fluid dynamics to simulate airflow through the nasal passage during both resting respiration and ram ventilation likely experienced during flight. Depending on the size and location of the antorbital sinus ostium, ram ventilation had the potential to aid in thermoregulation by pushing cooler air through the large, and presumably well vascularized sinus. Rostral expansion of the antorbital sinus could have additionally aided in brain cooling via expansion of this respiratory counter-current heat exchanger.

Technical Session 10: Soft Tissues & Taphonomy (Friday, November 4, 2022, 8:00 AM)

A *THESCÉLOSÁURUS* SPECIMEN WITH UNIQUE ANATOMICAL FEATURES PROVIDES ADDITIONAL EVIDENCE FOR THE DEFLATION AND DESICCATION MODEL OF DERMAL TISSUE FOSSILIZATION

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One of the most complete specimens of the ornithischian dinosaur *Thescelosaurus* from the Hell Creek Formation is MOR 979, an articulated skeleton preserving portions of fossilized dermal tissues. Preparation of the forelimbs revealed the presence of two widely spaced, subconical projections along the anterior margin of each radius that are strongly curved towards each other. Similar structures are unknown in other ornithischian taxa, and clear evidence of their function is lacking at this time. Additional minor morphological differences are present elsewhere in the skeleton (e.g., a vertically oriented quadrate shaft) that distinguish this

specimen from all other well-preserved specimens of *Thescelosaurus neglectus*. Two hypotheses are proposed to explain these differences: 1) MOR 979 represents a new species of *Thescelosaurus*; or, 2) these differences represent either individual variation or sexual dimorphism within *T. neglectus*. Discerning between these competing hypotheses is difficult at this time given the small number of well-preserved specimens of *T. neglectus* available for study. Patches of fossilized skin on MOR 979 are preserved tightly appressed to the lateral surfaces of the right femur, ilium, and manus, and a flap of displaced skin is present adjacent to the distal end of the right tibia. The manual and pedal unguals also show traces of the keratinous sheaths. The taphonomy and geochemistry of MOR 979 is remarkably similar to that of a specimen of *Edmontosaurus* sp. from the Hell Creek Formation that preserves extensive portions of dermal tissue (NDGS 2000). Those similarities include dermal tissues tightly adhered to the underlying bones, portions of dermal tissues displaced from their original anatomical positions, and an association of iron oxide cementation in the encasing rock in regions with well-preserved dermal tissues. We interpret MOR 979 as an example of dermal tissue preservation via the deflation and desiccation model (as opposed to the traditional rapid burial model) that allows relatively fragile dermal tissues to persist long enough postmortem to be entrained in the rock record. These specimens also reveal that a similar geochemical process fossilized their remaining dermal tissues after burial. Clarifying the details of this second step in the process will allow for specimens that have a high potential for preserving dermal tissues to be identified, reducing the risk of their damage or loss during collection and preparation.

Funding Sources This research was supported by a grant from the David B. Jones Foundation and by the State of North Dakota.

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

WHERE IN THE WORLD DOES THAT WHALE HAIL FROM? PALEOBIOGEOGRAPHY AND DISPERSAL HISTORY OF STEM MYSTICETES

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Two prevalent mysticete phylogenetic matrices were combined into a single supermatrix, and a stepwise random addition stepwise heuristic search was used to create a majority rule consensus tree of phylogenetic relationships among fossil and living baleen whales. To facilitate focus on stem Mysticeti the crown group was collapsed into a single branch represented by *Mauicetus parki*, leaving 3

archaeocetes, 5 basal odontocetes, and 39 stem mysticetes. Temporal and geographic distribution data for each of these operational taxonomic unit (OTU) was collected using the Paleobiology Database. The final dataset spanned from the Bartonian (Eocene) through the Burdigalian (Miocene), though most of the OTUs are from the Oligocene. Based on the geographic distributions, each OTU was assigned to one or more of eight areas: Southern Pacific, North Asian Pacific, North American Pacific, South American Pacific, The Gulf Coast of North America, North American Atlantic, The Tethys Sea, and Antarctica. The software Reconstruct Ancestral State in Phylogenies (RASP) 4.3 was used to estimate the ancestral areas of nodes on the phylogenetic tree. A Bayesian Binary Markov Chain Monte Carlo analysis was performed with 5,000,000 cycles using 10 chains. Results were limited to 5 areas maximum per OTU, and null areas were not allowed. Chains were sampled every 1000 generations with a temperature of 0.1, and the first 10% of runs were discarded as burn-in. The most likely ancestral range for the tree's basalmost mysticetes (undescribed specimens ChM PV 4745 and ChM PV 5720) was found to be the Atlantic of North America, 33.9-29.6 Ma. The ancestral range for a Mammalodontidae + *Borealodon* clade was found to most likely be the South Pacific by at least 33.9 Ma, though there was also support for a North American Pacific origin or a combination of the two. The analysis overwhelmingly supported a North American Pacific origin for the Aetiocetidae by 33.9 Ma as well, with species only later dispersing to Asia. While the Eomysticetidae were strongly suggested to have originated in the South Pacific by 33.9 Ma, the clade of Eomysticetidae + *Maiabalaena* and *Sistqwayk* is reported as having the strongest support for a North American Pacific origin. The clades of mysticetes closest to the crown, including *Horopeta* and *Mauicetus*, all are suggested to have arisen in the South Pacific from 33.9-28.4 Ma, suggesting this may be the location where the earliest members of the crown group evolved.

Funding Sources Funding was generously provided via the Presidential Scholarship awarded to the lead author by the George Mason University Department of Environmental Science and Policy.

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

LEFT BUT NOT FORGOTTEN: USING PHOTOGRAMMETRY FOR LONG-TERM PRESERVATION AND MANAGEMENT OF IN SITU PALEONTOLOGICAL RESOURCES: STORIES OF THE GOOD, THE BAD, AND THE UGLY

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It is well known that fossil vertebrate tracksites provide a wealth of valuable scientific information, not only about the characteristics of the trackmakers, but also insights into behavioral and community dynamics. As such, track surfaces are often stripped of their protective sedimentary covering to be mapped, studied, and hopefully photogrammetrically documented. In many cases, these surfaces are left exposed to natural weathering and human degradation (e.g., vandalism and carelessness). As these sites are often large, remote, and found on public land, it is usually not feasible to provide them with the level of protection warranted by their scientific and educational values. Unlike most body fossils (which are collected), vertebrate trace fossils are routinely left in place to preserve their context, frequently resulting in challenging management decisions. However, photogrammetry is increasingly being employed in the assessment, monitoring, and decision making of in situ paleontological resources. Although rarely used in paleontology prior to 1997, photogrammetry is currently considered state-of-the art and best practice in the noninvasive, 3D digital data collection of vertebrate trace fossils. The discovery of the Red Gulch Dinosaur Tracksite 25 years ago in Wyoming heralded in a new era of ichnological documentation and tracksite management. Bureau of Land Management (BLM) staff spearheaded the use of photogrammetry at this site and pioneered many techniques in photogrammetric ichnology. They remain on the forefront utilizing this technology for resource management today. Episodic photogrammetric documentation from various platforms (e.g., ground-based monopods and UAS) has been conducted by BLM staff at tracksites over the past 20 years. High-quality data sets are coaligned into the same coordinate space supporting direct visual and quantitative analysis. These data have proven invaluable for understanding morphological degradation of the tracks themselves, as well as the condition of track-bearing surfaces due to wrongful impact, including the recent well-documented impacts to Early Cretaceous ichnites at the Mill Canyon Dinosaur Tracksite in Utah. Photogrammetry is a powerful tool which allows public land managers to inventory, monitor, manage, and protect in situ paleontological resources using scientific principles and expertise, and make scientific-based management decisions to preserve these invaluable parts of America's Natural Heritage.

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

LATE CRETACEOUS IN THE BIG BEND REGION OF TEXAS: THE SOUTHERNMOST RECORD OF SPALACOLESTINE "SYMMETRODONT" IN NORTH AMERICA

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“Symmetrodonts” are uncommon components in microvertebrate assemblages, but the group is important because the molars are structurally intermediate between the simple cusp-in-line triconodont arrangement and more complex tribosphenic molars of therians. Six teeth representing spalacolestine “symmetrodonts” have been recovered from the Lowerverse Local Fauna, a diverse early-middle Campanian (c. 82-80 Ma) microvertebrate assemblage known from a single site in the lower shale member of the Aguja Formation near Big Bend National Park, Texas. These specimens represent a variety of tooth loci (four lower molars, a lower premolar, and an upper premolar), and pertain to two different species of *Symmetrodontoides* (including one new species) as well as an indeterminate spalacolestine. The presence of these specimens is significant. First, they represent the southernmost extent of spalacolestine “symmetrodonts” in North America; the majority of spalacolestines are from assemblages in Canada (Milk River Fm.), Montana (Eagle Fm.), and Utah (Wahweap Fm.). The Lowerverse specimens also represent the latest occurrence in North America, coinciding with the group’s extinction in the middle Campanian.

Technical Session - New Methods (Thursday, November 3, 2022, 10:15 AM)

A NOVEL PHYLOGENY-INFORMED MACHINE LEARNING METHOD FOR IMPROVED ACCURACY IN TAXONOMIC CLASSIFICATION

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Machine learning has recently become a popular tool in vertebrate paleontology for the taxonomic classification of isolated skeletal remains from morphometric data. Most studies focus on fossil teeth because of their taphonomic resilience and greater abundance relative to other elements. All such machine learning studies adopt a multiclass model, where specimens are labelled with a single taxonomic entity assumed to be independent from other entities. Classification accuracy is assessed on the percentage correctly classified from either the original data or a separate test partition. However, accuracy depends on the number and exclusiveness of the labels, and there is no a priori method to opt between labelling schemes.

To solve these shortcomings, we present a new classification model: phylogeny informed multi-label classification (PIMC). It assigns multiple binary labels to each specimen depending on its inclusion or exclusion from predefined monophyletic

groups. We used the automated machine learning package *autosklearn*, built on *scikit-learn*, to train and compare the accuracy of PIMC and multiclass models with morphometric datasets of theropod (N=1334) and sauropod (N=885) teeth. Both methods were trained on subsamples of the original dataset with varying sampling completeness types. The multiclass models followed three classification schemes differing in exclusivity; the most exclusive was approximately equal to the multiple labels of the PIMC models. Multiclass models were evaluated on the F2-score (weighted harmonic mean of precision and recall), whereas PIMC models were evaluated on the hierarchical accuracy, a new metric that benefits the exclusivity of the scheme.

The PIMC models for both datasets consistently outperformed multiclass models in their ability to classify test specimens to the least inclusive group. F2 scores of PIMC were between 10–40% better than the most exclusive multiclass model. Only the least-exclusive multiclass models had higher F2 scores than PIMC, but the increased resolution inherent to PIMC still makes it the preferred model. Incorporating information about nested phylogenetic relationships is commonplace for many comparative approaches but lags in numerical taxonomy. Its application is a natural approach to classification and critically avoids uninformative paraphyletic groupings. With evident accuracy and resolution gains over the multiclass model, we encourage its adoption and application in future studies.

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

PALEONTOLOGY AND SEDIMENTOLOGY OF LATE DEVONIAN VERTEBRATE-BEARING MARINE TO CONTINENTAL DEPOSITIONAL ENVIRONMENTS OF THE CATSKILL FORMATION, NORTH-CENTRAL PENNSYLVANIA, USA

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Upper Devonian strata worldwide record the emergence of continental ecosystems and the diversification of vertebrates. Fossil sites in Upper Devonian strata of north-central Pennsylvania preserve the transition from shallow marine to distal fluvial environments making these locations suitable for integrated paleontological-sedimentological studies. These transitional environments provided critical habitats for the diversification of vertebrates during the Middle to Late Devonian. Drab marine mudrocks and sheet sandstones of the marine Lock Haven Formation intertongue with the overlying continental redbeds of the Catskill Formation as they transition up-section into red mudrock and thin channel bodies of distal fluvial depositional environments. Trace fossils and

palynomorphs recovered from these strata confirm a transition from quiet water, shallow marine embayments to well-drained, fluvial–floodplain environments, where high sedimentation and weakly developed paleosols are recorded. Invertebrate taxa recovered from transitional marine to distal fluvial deposits include *Lingula* brachiopods and *Archanodon* bivalves. Vertebrate taxa recovered from transitional strata include “placoderms” (*Bothriolepis*, *Phyllolepis*, and dinichthyid arthrodires), acanthodians (ischnacanthids and *Gyracanthus*), and sarcopterygians (lungfish, *Holoptychius*), whereas *Langlieria* sarcopterygians and paleoniscid actinopterygians occur only in distal fluvial strata. In transitional and distal fluvial deposits, vertebrate fossils are primarily preserved as disarticulated and abraded plates, scales, and bone fragments indicating transport in high-energy waterways before deposition in channel-bar deposits. Partly articulated, unabraded vertebrate remains occurring in distal fluvial strata indicate deposition in floodplain settings resulting from crevasse-splay or overbank deposition. The occurrences of dinichthyid arthrodires and ischnacanthid acanthodians in transitional and distal fluvial and not in proximal fluvial environments of the Catskill Formation suggest that they were restricted to shallow marine and coastal plain environments of the Catskill Basin during this time. Most observed vertebrate taxa occur in both transitional and distal fluvial depositional settings suggesting that these taxa were euryhaline in their environmental tolerances likely allowing them to inhabit a spectrum of habitats from brackish to freshwater in the Catskill basin during the Late Devonian.

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

HORNCORE FRACTURE IN *ANCHICERATOPS* (ORNITHISCHIA, CERATOPSIDAE), AND THE OCCURRENCE OF PATHOLOGICAL HORN FRACTURES IN CERATOPSIDAE

Brown, Caleb M.

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Pathologies in fossils, especially when occurring across a large sample, can offer unique clues to behaviour in extinct animals. Ceratopsidae, is a clade of large bodied herbivorous dinosaurs known for their extensive cranial ornamentation, consisting of a nasal horn, paired postorbital horns, and hypertrophied parietosquamosal frill. These horns and frills of ceratopsians are some of the largest cranial ornamentals to ever evolve. *Anchiceratops ornatus* is a chasmosaurine ceratopsid, with large, dorsally directed and anterolaterally curving horns up to 68 cm long. A recently collected *Anchiceratops* partial skull (TMP 2017.007.0011) from the Horseshoe Canyon Formation (upper Cretaceous) of Alberta, bears a distinct horn pathology. The right horn is complete with a distinct apex, 617 mm long. The left horn is truncated to a length of 258 mm, with the broken apical margin characterized by rugose, remodeled bone texture and several distinct resorption pits. A second, isolated *Anchiceratops* horncore, shows a distinct fracture with a

pseudoarthrosis. At least four similar postorbital horn fractures have been described for *Triceratops*, including a nearly identical example in USNM 4708, as well as a single example in *Chasmosaurus*. Distinct unilateral horncore fractures have been documented in three phylogenetically disparate chasmosaurine taxa, potentially suggesting an ancestral behavioral cause. While resorption pits are a common feature of centrosaurine postorbital horns (e.g., *Centrosaurus apertus*), and appear to represent a non-pathological feature in late stage ontogeny, they are rare in Chasmosaurines where they often occur unilaterally, and coincide with a loss of much of the total horn length. A systematic review of the horns of several centrosaurine taxa (*Centrosaurus apertus*, *Coronosaurus brinkmani*, *Styracosaurus albertensis*) shows a low or negligible rate of horncore fracture (nasal and postorbital) in these taxa, despite large sample size. The contrast in the prevalence of horn fracture between these sister clades, suggests differences in horn behavioral use (i.e., intraspecific combat) between the clades, or a correlation with long vs short horned morphs within each clade.

Colbert Prize Session

TOOTH REPLACEMENT CYCLES AND THE ENDOCRANIAL ANATOMY OF A NEW ORNITHOPOD DINOSAUR FROM THE LATE CRETACEOUS OF ANTARCTICA

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Ornithopods are a group of herbivorous dinosaurs that were incredibly successful and diverse during the Cretaceous period. Fossil remains from this group have been found on all seven continents, demonstrating that ornithopods had a worldwide extent at their apex. Here we use computed tomographic (CT) scan data to investigate the dentary and partial braincase of a new ornithopod species from the Late Cretaceous of Antarctica. Using digital segmentation techniques, the dentition and neurovasculature were reconstructed from the dentary CT data, while the internal cavities that would have housed the endosseous labyrinth, cranial nerves and floccular lobe were reconstructed from the braincase CT data. The relationships between functional, replacement and non-functional old teeth at each tooth row was examined to investigate the different stages of tooth replacement in this new ornithopod. Reconstructed Zahnreihen patterns suggests an average z-spacing of 2.4, consistent with several similar ornithischians. The endomandibular neurovasculature was found to be relatively simple throughout most of the length of the dentary, but becomes very complex at the pre-dentary-dentary margin. The morphology of the digitally reconstructed floccular lobe is unusual in that it is forked, but also in how far it extends through the anterior canal of the endosseous labyrinth. Enlarged floccular lobes

have been linked to gaze stabilisation and rapid head movements in both extinct and extant theropods, indicating that this ornithopod may have had similar specialisations. These results inform us on the evolution of sensory abilities and dental systems within both ornithopods and other major dinosaur groups.

Funding Sources Central England NERC Training Alliance (CENTA) CENTA NE/S007350/1.

Preparators' Session (Thursday, November 3, 2022, 8:00 AM)

3D PRINTING POP-TOGETHER OSTEOLOGICAL MODELS: A DESIGN AND FABRICATION WORKFLOW

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Inspired by the work of Mr. Ramón Gonzalez, we set out to make 3D pop-together models of fossil vertebrate skulls where the individual bones are held in place by embedded magnets. While it is possible to simply drill small holes and insert magnets into the contact surfaces of the 3D-printed elements, that method presents several limitations. Small or fragmentary joint surfaces will not provide the contact area necessary to form a stable link. Additionally, if multiple copies are desired, each must be drilled and filled by hand. We developed a workflow where all of the modifications necessary to bridge gaps between elements and create magnetic housings are done digitally before 3D printing. While initially more labor intensive, working digitally gives us the ability to produce models that display a wider range of morphologies, make multiple copies with little additional effort, replace damaged parts, and easily redistribute the 3D printable files. To create several demonstration models, we used Avizo Lite (ThermoFisher Scientific) to segment the individual bones of the mandible of an adult *Alligator mississippiensis*; and obtained mesh files of other specimens available through digital repositories (e.g. MorphoSource and Sketchfab). We used the free program Meshmixer (Autodesk) to edit and modify the surface meshes.

The process of turning the mesh files into a magnetic pop-together model consists of eight major steps: Initial Print Optimization – removing unnecessary geometries and bridging of small gaps; Scaling – since the size of the magnets is fixed the final scale of the printed model must be set before further modifications can be made; Enforcing Edge Congruence – modifying the contact surfaces of each element to assure proper fits; Joining – adding the infrastructure needed to hold the magnets; Final Print Optimization; 3D Printing; Assessment and Modification – final fit tests and mesh revisions; and Final Assembly.

For the end user, assembling the model demonstrates the articulations between different bones and how they contribute to the structure of the skeleton. Disassembling a model allows for inspection of individual elements and reveals features that are not normally visible. Beyond simply illustrating relationships and concepts, the final printed models are a huge amount of fun to take apart and put back together, making them well suited for use in education and outreach.

Funding Sources Oklahoma State University Center for Health Sciences Department of Anatomy and Cell Biology

Virtual Posters

ISOLATED SKULL REVEALS A NEW TRIASSIC COELACANTH FROM TEXAS

Brownstein, Chase D.

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An intriguing pattern among extant lineages of vertebrates is the existence of depauperons: clades that have remained species-poor over huge time spans (i.e., >100 million years ago). Among these are so-called 'living fossil' fishes like gars, sturgeons, bichirs, and lungfish. Perhaps the most famous of these are the coelacanths, which are today represented by only two species yet are known from a fossil record comprising over 400 million years of evolution. Despite the high morphological and body size disparity observable in extinct coelacanths, the total number of species belonging to the coelacanth lineage Actinistia remains very low (<50). Here, I describe the skull of a large-bodied coelacanth from the Late Triassic Dockum Group of Texas. The new taxon is characterized by extreme mediolateral compression of the skull, representing a new morphology in Actinistia. Phylogenetic analysis shows that the Dockum taxon is stemward of the divergence—Latimeroidea—that produced all coelacanth diversity after the Triassic. As such, the new species demonstrates that coelacanths both proximal and far removed from the crown clade (*Latimeria*) were experimenting with new body plans up until the Triassic-Jurassic mass extinction.

Virtual Posters

HIGH MORPHOLOGICAL DISPARITY IN A BIZARRE PALEOCENE FAUNA OF FRESHWATER REPTILES

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The consequences of the K-Pg mass extinction are reflected across present biodiversity, but many faunas that appeared immediately after the extinction event were very different

from current ones. Choristodera is a clade of reptiles of uncertain phylogenetic placement that have an extremely poor fossil record throughout their 150-million-year history. Yet, choristoderes survived the K-Pg event and persisted until the Miocene. I describe the skulls and skeletons of two new choristoderes from a single Paleocene ecosystem in western North America that reveal the hidden Cenozoic diversity of this reptile clade. Despite their similar size, the new species deviate dramatically in morphology. *Kosmodraco magnicornis* gen. et sp. nov. possesses an extremely short snout and extensive cranial ornamentation. The sacrum of *K. magnicornis* bears enlarged muscle attachment sites and other modifications reminiscent of some giant crocodylians. In contrast, *Champsosaurus norelli* sp. nov. is a longirostrine species with an uninflated and ventrally divergent postorbital skull. Together with the North American choristodere previously classified in the European genus *Simoedosaurus*, *K. magnicornis* substantiates a new clade of giant, short-snouted taxa endemic to the Americas. *C. norelli* is found to be an early-diverging member of the *Champsosaurus* from the Cretaceous-Paleogene of the northern hemisphere. This suggests the presence of several ghost lineages of champsosaurid that crossed the K-Pg boundary. The new taxa greatly increase Cenozoic choristodere richness and strengthen the evidence for the existence of distinctive freshwater faunas in Paleogene Eurasia and North America, where this clade diversified to exploit newly available macropredatory niches in the aftermath of the asteroid impact. The new choristoderes also reveal the distinct ecological context in which extant freshwater predators of the Americas like alligatoroids and gars have their origins: Paleocene fluviolacustrine ecosystems in North America displayed high large predator diversity and morphological disparity relative to modern ones.

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

RECONSTRUCTING THE ECOLOGICAL RELATIONSHIPS OF LATE CRETACEOUS ANTARCTIC DINOSAURS AND HOW FUNCTIONAL TOOTH MORPHOLOGY INFLUENCED ECOLOGICAL NICHE AND DIET AMONG BASAL ORNITHOPOD DINOSAURS

Broxson, Ian D., Case, Judd A.

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The Sandwich Bluff Formation of the James Ross Basin of Antarctica has recently yielded a group of five late Cretaceous (Maastrichtian) non-avian dinosaurs that lived contemporaneously with each other, a first for Antarctica. These five dinosaurs include fragmentary remains of two differently sized elasmarian ornithopods, a hadrosaur, a nodosaur, and a possible megaraptor. In this study we will construct a model of the ecological relationships of late Cretaceous Antarctica. Additionally, we will look at what

specific factors allowed this group of four herbivores to coexist in a restricted locality and what niches were filled by each species.

To answer this coexistence question, this study will focus heavily on how functional tooth morphology influenced ecological niche and diet among these herbivorous dinosaurs. This assessment of tooth morphology has implications beyond these Antarctic herbivores and can be applied to many ornithischians as a whole. This study is the first of its kind to heavily analyze basal ornithopod dentition and its implications on diet.

A variety of skeletal parameters present among the Antarctic ornithopods and present in Australian and South American elasmarians were used to try to predict the body size of the Antarctic elasmarians. Based on this analysis for estimating the size of the Sandwich Bluff herbivorous dinosaurs we have been able to determine what layer of vegetation was potentially available to each dinosaur.

We also analyzed dental data of related Elasmarians from other Gondwanan landmasses to help determine functional morphology of the dentition of this group of dinosaurs. We have run preliminary tests of a Ranked Correlation (RC) between body size and tooth size with a very strong positive correlation and another RC analysis between tooth size and tooth morphology which only resulted in a positive correlation under certain conditions. Finally, in this study we will perform an in-depth analysis of the macrofloral and pollen data of the James Ross Basin in the late Cretaceous to compare to vegetation of other Gondwanan landmasses to determine the role of the functional tooth morphology of the Sandwich Bluff herbivorous non-avian dinosaurs and a construction of an ecological model of this Maastrichtian Antarctic ecosystem.

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

EXTREME DENTAL VARIATION WITHIN A SPATIALLY AND TEMPORALLY CONSTRAINED POPULATION OF FOSSIL BADGERS HIGHLIGHTS THE PITFALLS OF DESCRIBING NEW SPECIES BASED ON SMALL SAMPLES

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Vertebrate paleontology often suffers from a poorly sampled, fragmentary fossil record, wherein species are named and described based on limited material from a single individual. On the other hand, some localities offer large samples, thereby providing a better representation of the morphological variation. An interesting example of both scenarios is the Woodland Badger from the Gray Fossil Site of eastern Tennessee, *Arctomeles dimolodontus*. When originally

described in 2004, the only material available, and hence designated the holotype, was the upper dentition from a single subadult. While unique enough to warrant a new species, an understanding of the range of variation was lacking. Since that time, additional cranial material (MNI = 5), including jaws with lower dentition, sheds light on the extreme variation of some characters, relative to others. While regional/geographic variation cannot be explored because *A. dimolodontus* has yet to be recovered from any other locality, it can be ruled out; thereby offering a unique opportunity to study interspecific variation from a single locality. Hence, we highlight the individual morphological variation observed within the sample of *A. dimolodontus*, compare to the variation seen in modern badger samples, and discuss the implications when analyzing the morphology of vertebrate species that exhibit considerable interspecific morphological variation. Examples include, but are not limited to, the presence or absence of certain accessory cusps, cusp size and morphology, and size of certain teeth (relative to others). Some of the observed variation has been preliminarily attributed to sexual dimorphism, such as the presence of a sagittal crest; tall, curved, and broad zygomatic arches; and a robust rostrum in ETMNH 10880. However, other variations seem to truly represent alternate character states in previously defined diagnostic features. Significance of the variation observed here not only calls into question previously named species with similarly small samples, but also has implications with respect to cladistic analyses.

Funding Sources Funding was provided by the East Tennessee State University Department of Geosciences and the Don Sundquist Center of Excellence in Paleontology.

Virtual Posters

THE MICROSTRUCTURE OF RIBS IN LITHOSTROTIAN TITANOSAURS REVEALS DIFFERENCES IN THE TIMING OF BONE APPPOSITION FROM EARLY-DERIVING NEOSAUROPOD PATTERN

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Neosauropods comprise the largest terrestrial vertebrates. The life history of these reptiles is marked by continuous growth, due to the microstructure of appendicular bones, with scarce growth marks (i.e., Lines of Arrested Growth—LAGs).

Different from early-deriving neosauropods, the early remodeling in titanosaurian appendicular bones erases most details of its life history. Recently, thin sections of the rib cage of early-deriving neosauropods showed numerous growth marks and a potential proxy to access life history traits, although ribs are not directly associated with the increase of body mass as appendicular bones. Here, we sectioned cervical and dorsal ribs, as well as haemal arches of three lithostrotian titanosaurs *Austroposeidon*, *Gondwanatitan*, and *Maxakalisaurus*, from distinct lineages and body sizes. The decrease in the distance between LAGs in different ribs and the advance in remodeling indicate that all individuals reached at least sexual maturity. All analyzed periosteal bones exhibit two main depositional phases: a fast earlier modular phase, dominated by fibrolamellar bone with scarce growth marks in the inner cortex; and a later more cyclical phase, dominated by parallel-fibered bone and numerous growth marks in the outer cortex—associated in some regions with the deposition of an external fundamental system. The posterior portions of the cervical ribs differed from the main pattern by the presence of dense remodeled metaplastic bone, rich in Sharpey's fibers. Such microstructure supports the Tensile Member Hypothesis, in which tensile forces are dislocated from the anterior to posterior portions of the long neck. The dorsal ribs were the best samples to access life history traits in the specimens, since an extended modular and abbreviated LAG-dominated period is presented, unlike in early-deriving neosauropods. Both *Gondwanatitan* and *Maxakalisaurus* showed more parallel-fibered bone than *Austroposeidon*, whereas the last exhibited the *pneumosteum* in the endosteal bone, indicating pneumatization of the dorsal rib. Such distinctions among lithostrotians could contribute to the rapid increase of bone mass and volume, via bone pneumatization. In comparison with early-deriving neosauropods, the abbreviated LAG-dominated period of lithostrotians is a difference in bone appositional phases' timing, which could indirectly contribute to the diversity of body sizes among titanosaurs.

Funding Sources CNPq; PROANTAR-CAPES; FAPERJ

Technical Session 8: Evolutionary Developmental Biology (Thursday, November 3, 2022, 1:45 PM)

STERNAL EVOLUTION IN SYNAPSIDA: ELEMENT ASSEMBLY AND LOSS

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Paleontological, comparative, and developmental evidence confirms that the sternum of living synapsids is a composite structure, composed of two ancestrally independent elements, the interclavicle and the sternal bands. Both elements are paired and of predominantly lateral plate mesoderm origin, but immunofluorescent labeling and *Hox* gene expression mapping in the perinatal mouse document differences in their

sites of origin and developmental programs. Both elements also show internal discontinuities of structure and/or development. Ribs articulate only with the sternal bands in two styles differentiated by location, joint type, and association with sternbrae. Thoracic rib 1 (T1) articulates with the anterior sternal bands in a synostosis and is not associated with a sternbral boundary. More posterior ribs articulate with the posterior sternal bands in synovial joints associated with sternbral boundaries. Early “pelycosaur” synapsids had a midventral interclavicle. Although likely present, sternal bands were apparently not ossified. All rib articulations of basal therapsids mimic the T1 articulation of living mammals, identifying this as the ancestral character state. The innovation of more moveable synovial rib articulations and sternbrae posterior to T1 in cynodonts may be functionally associated with changes in posture and ventilatory mechanics. The integration of the interclavicle and the anterior sternal bands into a presternum was relatively recent, occurring only in therians. The developmental independence of sternal elements is signaled by element-specific modifications in living mammal subgroups and by the sequential loss of elements that accompanied feeding transitions in mysticete cetaceans. Posterior sternal bands and post-T1 rib articulations occurred in basal chaeomysticetes. Balaenids and cetotheres retain only the interclavicle and the anterior sternal bands, and have a bony articulation for the T1 rib. The sternum of balaenopteroid mysticetes lacks all bony rib articulations and is interpreted here as lacking the sternal bands entirely, retaining only the interclavicle. The differential assembly, modification, and loss of sternal elements highlights the ability of composite structures to respond to diverse selective environments over evolutionary time.

Colbert Prize Session

THE CONTRIBUTION OF SOFT TISSUES TO THE NECK OF PTEROSAURS

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Pterosaurs have a long, mobile neck that is divided into morphologically different parts, which leads to changes in the shape and extent of soft tissue attachment sites along the neck and may reflect soft tissues efficiency. Here, we established the arrangement of the pterosaur cervical series at rest, inferred which soft tissues were present and determined the maximum potential of the force exerted by the cervical musculature to determine their contributions to cervical stability and mobility. We analyzed specimens pertaining to *Anhanguera piscator* (NSM-PV 19892), *Azhdarcho lancicollis* (ZIN PH, several specimens) and *Rhamphorhynchus muensteri* (MGUH 1891.738), due to their three-dimensional preservation. Levels of zygapophyses overlap, soft tissues attachment sites, and muscle volume were observed in dissected specimens of extant birds and alligators as correlates in pterosaurs, based on the Extant Phylogenetic Bracket criteria. The maximum strength potential of the muscles was

obtained by multiplying the value of the largest functional cross-section and the value of muscle stress. The arrangement of the partially overlapping zygapophyses when the neck is at rest allows for longer intervertebral spaces between the posterior cervical vertebrae, which contributed to a slightly sinuous resting position in all species. The muscles *transversospinalis capitis* and *cervicis, complexus, longus colli* and *rectus capitis ventralis* presented the greatest strength potential, which may have ensured extensive dorsoventral neck range since these muscles would perform extensor and flexor activities. The inferred *ligamentum elasticum interspinale* and *interlaminare* would likely facilitate restoration of the neck to the resting position. The muscles *interspinales, intercostales, longissimus capitis profundus* and *flexor colli* presented the lowest potential for maximum strength. This indicates that *interspinales* and *intercostales* had a limited role in cervical stabilization, as the *ligamentum collaterale* and *ligamentum nuchae*. The low strength potential of the *longissimus capitis profundus* and *flexor colli* may be related to the existence of stronger muscles that perform lateral incursions, such as the *longissimus capitis superficialis* and *rectus capitis lateralis*. Therefore, strong extensor and flexor muscles indicate a dorsoventrally flexible neck and segmented muscles and ligaments contributed to stability in a resting position.

Funding Sources Funding provided by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior and Conselho Nacional de Desenvolvimento Científico e Tecnológico

Romer Prize Session (Thursday, November 3, 2022, 8:00 AM)

PERMIAN PILOTS: FLYING WITH THE FIRST GLIDING REPTILES

Buffa, Valentin

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Weigeltisaurid reptiles from the late Permian of Madagascar and Europe, are the first known gliding tetrapods. These reptiles show rows of long bony spars on either side of the body that have long been considered as a patagial skeleton. However, little is known of the relationship between these spars and the rest of the body, or of the actual gliding performances of these animals.

I provide here the first evidence of a one-to-one articulation between the patagial spars and gastralia in well-preserved weigeltisaurid specimens from Madagascar and Western Europe. The wing thus emerged from the ventrolateral side of the body wall, contrary to the more dorsal wing of extant gliders with rib-supported wings. Based on these new anatomical data, I present a fleshed-out reconstruction of the best-known weigeltisaurid *Coelurosauravus elivensis* that can be used for biomechanical analyses. This actualistic reconstruction is based on the adaptation and reshaping of the skeleton and soft-tissue of a CT-scanned specimen of the

agamid *Draco volans* to the reconstructed skeleton of *C. elivensis*. Volumetric body-mass estimates of this model indicate that *C. elivensis* was much lighter than previously thought, of comparable mass and wing loading to large mammalian gliders.

I then employ Computational Fluid Dynamics (CFD), a method that simulates the flow of a fluid around a solid object, to compare the gliding performances of *C. elivensis* and *D. volans*. These simulations cover a panel of angles of attack and flight speeds. I also employ various postures, changing camber and forelimb positions to reflect the diversity of flight conditions observed in *D. volans* and inferred for weigeltisaurids. My results indicate that both *C. elivensis* and *D. volans* generate an under-pressure and vortices above the wings, especially for high angles of attack, showing convergent adaptations to lift generation during gliding. Like *Draco*, weigeltisaurids could have been able to control lift and drag generation by adopting different postures in flight, enabling them to cover more distance. Based on new anatomical features, I thus reconstruct behavioral adaptations in the first fliding reptiles. This study also highlights how CFD analyses can provide detailed information on locomotor performances in both extant and extinct gliders, and has great implications for paleobiological studies in aerial or aquatic tetrapods in general.

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

ANALYSIS OF A THREE-DIMENSIONAL MUSCULOSKELETAL MODEL OF THE FORELIMB OF *GUANLONG WUCAI* (THEROPODA: TYRANNOSAUROIDEA)

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The function of the highly reduced and modified forelimbs of late-branching tyrannosaurs such as *Tyrannosaurus* has long been the subject of speculation and study, but most prior studies have not considered the evolutionary context of forelimb morphology. The earliest members of Tyrannosauroidea were relatively small-bodied and possessed gracile, elongate forelimbs, as typified by *Guanlong wucaii*. The overall morphology of the forelimb in *Guanlong* is similar to that of earlier theropods, but its phylogenetic position and the completeness of the preserved forelimbs make this taxon an ideal choice to serve as a model for plesiomorphic forelimb biomechanics within the clade. Comparative analyses of muscle moment arms can identify habitual limb postures and changes in muscle function over evolutionary lineages, and can be used to assess existing hypotheses of limb function. As part of a larger study, we constructed a three-dimensional (3D)

musculoskeletal model of the forelimb of *Guanlong* using a standardized software workflow in order to analyze potential forelimb function in this taxon as well as serve as a basis for future comparisons. The model was constructed by: 1) rearticulating the individual forelimb elements in a neutral reference plane and defining joint axes; 2) reconstructing muscle origins, insertions, and lines of action in 3D based on prior reconstructions of theropod forelimb musculature; and 3) placing the limb in a realistic posture and limiting movements to prevent joint disarticulation. Muscle moment arms for each muscle were then calculated across a wide spectrum of potential limb positions to investigate potential functional signals and allow comparisons between different taxa. For instance, comparisons of the moment arms of muscles involved in shoulder flexion and extension with those of the bipedal, herbivorous sauropodomorph *Mussaurus patagonicus* reveal the shift of several muscles for increased shoulder extension moments (e.g., deltoideus muscles), reflecting a potential emphasis on holding prey in *Guanlong*. This musculoskeletal model of the forelimb of *Guanlong* provides an important basis for comparisons with future 3D models of other tyrannosaur forelimbs, as well as offer insights about forelimb function among gracile-limbed theropods, which have received comparatively less biomechanical study.

Symposium: International Community Connections
(Wednesday, November 2, 2022, 1:45 PM)

DESIGNING INTERACTIVE EXPERIENCES IN ONLINE PALEONTOLOGY EDUCATION: GAMIFICATION, VIDEOS, QUESTS, BROADCASTS, FOSSIL EXPEDITIONS, AND OTHER NOVEL IDEAS FOR MAKING ONLINE CLASSES FUN AND EXCITING

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Paleontology education has seen a transformation from a primary field and laboratory experience to an increasingly online experience for many college students. These networked-based methods of instruction have expanded education accessibility and the range of student enrollment geographically, but also have come at a cost of increased student isolation. During the 2020-2021 global pandemic, many students and instructors have felt overwhelmed with the shift to online learning and the accompanying remoteness. Facing this issue, new methods and resources are needed to improve instructional delivery and facilitate greater student engagement. To achieve this goal two synchronous online courses at Utah State University were redesigned using cooperative games in which the courses became game like adventures for student participation. A freshman Earth Science class and upper division course on dinosaurs were redesigned. The dinosaur class had students propose expeditions to collect dinosaurs for a fictitious museum; the freshman Earth Science class had a more complex story with puzzles, ciphers, virtual

reality rooms and escape room like elements in a storyline about space travel and recreating a new Earth-like planet. The concept of learning centered on the idea of individual student quests. Quests are story lead instructions for individual students to seek out information from a series of clues in order to discover key codes. These key codes are reported to fellow team members, as well as what the students learned while conducting their personal quests. Together the teams decide on how to use these keys to unlock virtual locks, which advances the story. Team choices affect the outcome of the game, but do not affect the team's grade. The collaborative nature of engaging students in this game-like environment provided a unique opportunity for peer-to-peer interaction. Post course surveys showed a 14% increase in rating of the classes as excellent, while students also highly ranked the instructor with a 12% increase prior to the redesign. Students strongly agreed that the instructor engaged the students in learning 93.3% (up from a prior 50%). While these methods have major advantages, they also have limitations: class sizes below 25 are ideal with larger enrollments difficult to administer, absenteeism can cause problems in team outcomes, as well as the fact that these exercises require an increase in instructor time and effort.

Technical Session 9: Mammals (Friday, November 4, 2022, 8:00 AM)

INVESTIGATING THE ROLE OF DEVELOPMENTAL MODULARITY AS AN EVOLUTIONARY MECHANISM WITHIN RODENT MOLARS

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A challenge to understanding evolutionary mechanisms is understanding how embryonic development influences patterns of phenotypic change. The first lower molar (m1) of rodents is an example of this challenge where outstanding questions remain despite considerable previous work. Prior studies on tooth morphogenesis in model systems (e.g., *Mus* and *Rattus*) identified potential developmental anterior and posterior modules. These modules appear compatible with a relatively consistent pattern in rodent evolution in which anterior ends of m1s appear more evolutionary labile, but a causal connection has not been tested. The Sagebrush Vole, *Lemmiscus curtatus*, represents an excellent system for testing this potential relationship. Over the past four million years, *Lemmiscus* evolve additional closed enamel triangles on the anterior portion of the m1, while the posterior portion of the m1 is characterized as more stable. This anterior-posterior contrast presents an opportunity to investigate if the proposed anterior-posterior developmental modules can explain this evolutionary pattern.

I sampled 64 individuals from across the geographic and temporal range of *Lemmiscus* to investigate the hypothesis that evolution of m1 shape can be decomposed into anterior and

posterior modules. Crown surface shape of the m1 was quantified using a dense sampling of 988 patch-based morphometric landmarks. Strong signals of integration and weak to non-existent signals of modularity were recovered contrary to expectations. Further investigation examined patterns of variation to reconcile these results. This revealed that variation found within the anterior portion of the m1 is more broadly distributed among multiple enamel ridges, and not primarily on the anterior-most enamel triangle. I also recovered a higher-than-expected amount of variation at the posterior end of the tooth, specifically within the posterior loop, where it contacts the m2. This result suggests that m1 shape variation may be more impacted by the shape of the m2 than previously thought. Taken together, results can help explain how developmental modularity might not be a core driver of the evolutionary patterns; i.e., variation is more broadly distributed than expected under an anterior-posterior modularity hypothesis. Future work will focus on modularity, integration, and shape evolution of the tooth row to further elucidate these findings.

Colbert Prize Session

SPECIES DISTRIBUTION MODELING (SDM) OF SEVERAL EMYDIDS IN LATEST PLEISTOCENE NORTH AMERICA WITH IMPLICATIONS ON THE IDENTIFICATION OF *GLYPTEMYS INSCULPTA* IN THE AMERICAN SOUTHEAST

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The study and identification of Pleistocene herpetofaunas in North America has largely been dominated by the North American Herpetofaunal Stability Hypothesis, which states that the distributions of most reptiles and amphibians remained unchanged throughout the Quaternary of North America. Researchers have criticized this idea due to the known climatic changes that occurred during that time as well as on the fundamental identifications of skeletal specimens. Use of local specimens skewed the original identifications and strong osteological characters and standards have not yet been applied for many taxa. However, reports of extralimital taxa do exist. *Glyptemys insculpta* has been reported over 600km south of its current range at Cheek Bend Cave, TN and Ladd's Quarry, GA. Material for the taxon at these sites include a partial carapace at Cheek Bend Cave and a partial plastron and pleural from Ladd's Quarry. As *G. insculpta* is an extralimital taxon due to its fossil presence in the southeastern US, it serves as a focus for this study. Here I present the use of Species Distribution Modeling (SDM) to predict the potential distributions of several emydid turtles during the latest Pleistocene of eastern North America. The resulting models all had high AUC scores (>0.8) indicating confident results. Models using the same parameters and Holocene climate data were reflective of historical distributions suggesting the climatic parameters are accurate. The models show several

drastically different distributions for *G. insculpta* but also for other emydids such as *Emydoidea blandingii* and *Terrapene carolina* during the latest Pleistocene. Cheek Bend Cave and Ladd's Quarry did not fall within predicted distributions of the *G. insculpta* models, indicating either an inaccuracy with the model or a misidentification of the material. Interestingly, models for *E. blandingii* include both localities within their distributions suggesting that taxon as a potential alternative identification. The material referred to as *G. insculpta* from these localities requires further morphological study. Results of the SDM used in this study indicates that multiple emydids had significantly different distributions during the latest Pleistocene in contrast to previous hypotheses.

Virtual Posters

MEGATHEROPOD MORPHOLOGIC DISPARITY AS A PROXY FOR UNDERSTANDING STRUCTURING OF MESOZOIC ECOSYSTEMS

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During the Mesozoic, apex predatory niches were occupied by taxa from one of four major non-avian theropod lineages: allosauroids, tyrannosauroids, ceratosauroids, and spinosaurids. Various hypotheses have been put forth to explain how these megatheropods managed to coexist, including taxonomic replacement, niche partitioning, and ecosystems structured ontogenetically. While we cannot directly observe these ecosystems to describe ecological patterns, various quantitative approaches allow us to assess how changing morphology and diversity might be indicative of ecosystem structuring. In this project, morphologic disparity and taxonomic diversity were modelled using the package Claddis in the freeware program R based on recent published phylogenetic matrices for allosauroids, tyrannosauroids, ceratosauroids, and spinosaurids. Correlated trends in disparity and diversity within a lineage might be indicative of macroevolutionary processes within the respective ecosystems; for example, elevated levels of both diversity and disparity would suggest periods of intense competition where one lineage may be speciating and experimenting with new morphologies. Overall, results of this study indicate that tyrannosauroids were significantly more disparate ($p < 0.05$) than either of the other megatheropod lineages with high disparity early in their radiation and lower disparity in the Late Cretaceous, despite high diversity. This may indicate stabilizing selection around the classic tyrannosaur bauplan. Allosauroids were highly diverse in the Jurassic but declined while disparity remained relatively consistent, indicating a potential replacement scenario or competitive exclusion by other carnivores. Ceratosauroid diversity also peaked in the Late Cretaceous and was correlated with a drop in disparity ($r^2 = 0.72$, $p = 0.001$), which may be indicative of a radiation of the blunt-snouted abelisaurids like *Carnotaurus*. Spinosaurid diversity and disparity remained low, which could reflect aquatic

specialization within the lineage or poorer sampling of their fossil record relative to other groups. Future analyses at the ecosystem level may show whether these trends represent actual restructuring or background biotic changes.

Technical Session 13: Early Archosaurs & Pterosaurs (Friday, November 4, 2022, 1:45 PM)

ELEVATED AEROBIC CAPACITY IN TRIASSIC ARCHOSAURS SUPPORTED BY MODELED REDUCTIONS IN RED BLOOD CELL SIZES

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Erythrocyte size is a critical determinant of the rate of diffusion of gases between the environment and the capillary beds of the gas exchanger, and between the blood and organs. Smaller red blood cells (RBCs) facilitate transport of O_2 across tissue barriers. RBC size correlates with the diameter of capillaries in organs and, importantly, these vessels leave a signature in bone in the fossil record. Small RBC size causes faster O_2 uptake in the lung, and faster delivery of O_2 in muscle. Therefore elevated aerobic capacity correlates with smaller RBC size in virtually every vertebrate clade studied. RBC size in extinct archosaurs is relatively unknown in part due to lack of fossilized soft tissue preservation, but also because it has not previously been appreciated that RBC size leaves an indirect trace in fossil bone. Inference of RBC size of extinct archosaurs in a phylogenetic context can provide information on the relative timing of increases in activity levels during the Triassic. Here, we use histologic sections of limb bones to obtain osteocyte lacuna volume, harmonic mean canal diameter, and canal minimum caliber to estimate RBC length, RBC width, and RBC area in extinct archosaurs using phylogenetic eigenvector maps. We included 14 extinct members sampled from Archosauromorpha, Archosauriformes, Poposauroidea, Silesauridae, Crocodylia, Ornithopoda, and Theropoda, eight extant avians, and one extant crocodylian to improve predictive power on an analysis previously used to study mammalian RBC size reductions. Limb bone histology and blood smears of extant archosaurs were incorporated for estimation of RBCs in the fossil taxa. Our results support a Triassic decrease in RBC sizes in the

archosauromorph *Prolacerta broomi*, the early-diverging archosauriform *Euparkeria capensis*, and in early avemetatarsalians, or convergent reductions in these three lines. The relative timing suggests that RBC size reductions may have coincided with morphological innovations that enabled an elevated aerobic capacity (e.g., a thinner blood-gas barrier via avian-style respiratory system, specialized calcaneus and astragalus, among others). These data also highlight the need to investigate specific groups within extinct archosaurs to better understand the relationship of RBC size and novel life habits, such as small RBCs in the volant Pterosauria, RBC size and posture within Archosauriformes and Pseudosuchia, and small RBC size in the early members of Ornithopoda.

Technical Session 4: Paleobiogeography (Wednesday, November 2, 2022, 1:45 PM)

NEW NEOTROPICAL FOSSIL TURTLES FROM COLOMBIA, VENEZUELA, AND PANAMA; PALEOBIOGEOGRAPHICAL AND EVOLUTIONARY HISTORY IMPLICATIONS

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Northern South America and the Isthmus of Panama constitute regions where key dispersal, evolutionary and geological events occurred and produced the extant geographical and biodiversity of Neotropical turtles. Despite of relevant discoveries in these regions in the last two decades; the whole picture of the Neotropical turtles evolution is still poorly understood. Here, I present and summarize the most recent fossil finds of Neotropical turtles from Colombia, Venezuela and Panama, and discuss their paleobiogeographical and evolutionary history implications. The first findings come from the well-known fauna of La Venta, Tatacoa Desert, south central Colombia. Fossils from this region include the first record of the genus *Mesoclemmys*, the first skull and excellently well-preserved shell of a juvenile specimen of the giant *Stupendemys geographica*, the first occurrence of *Caninemys tridentata* outside Brazil, and new fossils of *Chelus colombianus* (*colombiana* for some authors), and a new fossil species of *Podocnemis*. New fossil turtles from Venezuela come from the Urumaco region, including the largest specimen of *Stupendemys geographica* (2.86 m), which at the same time is the largest freshwater turtle ever recorded, as well as new findings of *Chelus lewisi*, which serve to discuss biogeographic differentiation in two taxa (extant and fossils). Together, the new Colombian and Venezuelan record of turtles shows the extensive distribution that several lineages of Neotropical turtles had in the Miocene Pebas wetland system, in addition to serving to strengthen conservation plans for some highly endangered extant species of *Mesoclemmys*. Finally, remains of a marine turtle from the middle to late Miocene, Chagres Formation of Panama are preliminarily described. All these fossils are placed in a updated

phylogenetic context, and paleobiologic considerations are also discussed.

Funding Sources Banco de la República de Colombia (grant 4381). Universidad del Rosario (Capital Semilla IV-FCS018, 2019). Alexander von Humboldt Foundation Equipment Subsidy grant

Technical Session 9: Mammals (Friday, November 4, 2022, 8:00 AM)

DID ABUNDANT ANTS LEAD TO ABUNDANT ANTEATERS? ASSESSING THE LINK BETWEEN ANT AND TERMITE ABUNDANCE AND THE DIVERSITY OF OBLIGATE MYRMECOPHAGES IN EXTINCT AND EXTANT XENARTHRA

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Myrmecophagy, or the consumption of ants and termites, has evolved multiple times in mammals along with a suite of morphological traits to exploit large colonies of these insects (e.g., termite mounds). Extreme adaptations in obligate myrmecophagous species include a narrow or tube-like skull, long tongue, modified hyoid apparatus, simplified or lost teeth, and large claws. These adaptations are particularly well-represented in Xenarthra by the anteaters and tamanduas (*Xenarthra*, *Pilosa*, *Vermilingua*) and several genera of armadillos (*Xenarthra*, *Cingulata*). Ant and termite abundance has increased throughout the Cenozoic, peaking during the Eocene (ants) and Miocene (both ants and termites). Whether abundance of ants and termites is correlated with rapid evolution of specializations for myrmecophagy or increases in speciation rates in myrmecophagous clades is unclear. We thus tested the hypothesis that rates of character evolution and speciation in obligate myrmecophagous xenarthrans increased along with the abundance and diversity of ants and termites using Bayesian phylogenetic methods. We compiled a total evidence phylogenetic matrix with 366 morphological characters and mitochondrial genomes for 51 extant and extinct xenarthran genera from published sources. We then estimated three time-calibrated phylogenetic trees: a fossilized birth-death total evidence phylogeny, a fossilized birth-death molecular phylogeny of living xenarthrans, and a birth-death skyline total evidence phylogeny. These phylogenies formed the basis for statistical analyses of rates of character evolution, overall speciation rates, and branch-specific speciation rates, focusing particularly on times of peak ant or termite abundance at 34, 16, or 15 Ma. Our analyses found different rates of character evolution between xenarthran clades. Some characters, such as fusion of the mandibular symphysis, evolved at different rates among obligate myrmecophages compared to non-myrmecophagous clades. Overall speciation rates show an increase after 15 Ma in the birth-death skyline

analysis; however, species-specific rates varied in the analysis of living species, with the greatest increase found in a clade of opportunistic, rather than obligate, myrmecophages. Results suggest that although some of the enigmatic morphology of obligate myrmecophages may have evolved at higher rates across Xenarthra, generalist clades evolved faster overall than those adapted specifically for myrmecophagy.

Technical Session 11: Synapsida (Friday, November 4, 2022, 8:00 AM)

PRELIMINARY PALEOHISTOLOGICAL INVESTIGATION OF *DIMETRODON TEUTONIS* FROM THE BROMACKER LOCALITY OF GERMANY

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Nearly a dozen species ascribed to the sphenacodontid *Dimetrodon* have been named from Early Permian and mainly North American localities. These animals, commonly interpreted as the dominant terrestrial predators of their time, ranged in estimated body weight from 37 kg (*D. natalis*) to 250 kg (*D. angelensis*). A single species, *D. teutonis*, has been recovered outside North America from the Bromacker locality of Germany and is hypothesized to be the smallest *Dimetrodon* species known to date, reaching an adult body-weight of 24 kg. *D. teutonis* material is scarce, but the best preserved specimen (MNG 10654) comprised of a few small appendicular elements, was assigned to a fully mature individual based on anatomical features.

Previous studies have examined the bone microstructure of some North American *Dimetrodon* species, including the diminutive *D. natalis*. These works consistently reported on the presence of highly vascularized (incipient-) fibrolamellar tissue in the thick cortices of limb bones and neural spines, suggesting a general high growth rate for these basal synapsids.

Here we investigate, using micro-computed tomography and petrographic thin sections, the bone microanatomy and histology of the largest known specimen of *D. teutonis* (MNG 10654) in order to further test the hypothesis that this individual represents an adult of a diminutive species and compare its paleobiology to coeval North American species.

All sampled elements (humerus, tibia and fibula) have surprisingly thin compact cortices, comprised of a poorly vascularized parallel fibered bone. Closely spaced LAGs near the periosteal surface suggest the presence of an external fundamental system.

Our preliminary observations support the claim that MNG 10654 constitutes a somatically mature individual of a diminutive *Dimetrodon* species. Moreover, its thin and poorly vascularized cortices contrast with previous reports on the histology of *D. natalis* and larger species. We propose that *D.*

teutonis might have grown slower than its North American relatives. Additional sampling will be needed to test our hypothesis.

Funding Sources This research project is funded by the Federal Ministry of Education and Research of Germany

Technical Session 16: Hoofed Mammals (Saturday, November 5, 2022, 8:00 AM)

NEW INSIGHTS ON THE DIVERSIFICATION OF HORSES

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Horses were common elements of Cenozoic communities, and reached high diversity during the Neogene. Their rich fossil record has inspired theories of cladal trends and progressive evolution that are still referenced in textbooks and resound in the collective imaginary. Yet, quantitative accounts of their diversification have been so far limited to the early Miocene cladogenesis of the subfamily Equinae (equines, the so-called ‘grazing horses’), interpreting raw diversity counts at face value. In order to reassess key aspects of their taxonomic and phenotypic diversification, we gathered an expansive dataset for fossil horses, including their global paleontological record, a distribution of informal supertrees, and detailed data of their body size and relative tooth crown height (hypsodonty) for over two hundred species. Using diversification models and phylogenetic methods, we reconstruct speciation and extinction in for the group and interpret these trends in the context of their phenotypic evolution. We found that fast species proliferation (speciation rate) was not restricted to equines, but was a shared feature in both anchitheres and equines, likely stemming from the more changeable environments of the Neogene. The fast early-phase radiation in the subfamily Equinae was likely the result of reduced extinction rates and higher lineage survival rather than a substantial acceleration in speciation. The evolution of body size and hypsodonty was not faster in regions of the phylogeny with faster diversification, suggesting a broad-scale decoupling of ecomorphological and taxonomic diversification. Our phylogenetic modeling approach reveals that major phenotypic trends were not caused by phyletic progression, derived from sustained, ubiquitous directional selection, but more likely were the outcome of differential lineage-level survival and multiplication (species sorting).

Funding Sources Funding for this project was provided by the Talent Attraction Program of the Madrid Government (no. 2017-T1/AMB5298).

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

USING TRACE ELEMENTS TO CHARACTERIZE THE GEOCHEMICAL HISTORY OF THE HANSON RANCH BONEBED, CRETACEOUS LANCE FORMATION, WYOMING

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The Hanson Ranch (HR) Bonebed is a monodominant assemblage of *Edmontosaurus annectens* and infrequent remains of other vertebrates within the Lance Formation of northeastern Wyoming. This bonebed, which from five main quarries has so far yielded more than 13,000 individual bones, is interpreted to have formed by deposition of a clastic debris flow, forming a normally-graded, fossil-dense assemblage. To clarify the geochemical history of the HR Bonebed and establish a baseline for similar analyses of the many other bonebeds and sites within the Lance Formation in the region, we conducted trace element analyses of 12 bones from the HR bonebed using LA-ICPMS. We chose to study trace elements like uranium (U) and the rare earth elements (REEs) because trace element signatures within fossils are known to record detailed clues about the biostratigraphic and diagenetic history of bonebed assemblages. A majority of the examined bones exhibit rapidly declining REE profiles, indicative of rapid and brief trace element uptake. Ternary diagrams and whole-bone spider plots of shale-normalized REE concentrations revealed significant variation among specimens. The bones were found to display a lack of correlation between U concentrations and (Ce/Ce^{**})_N anomalies, suggestive of contrasting timescales of uptake of these respective elements. Many, but not all, of the bones acquired a positive (Ce/Ce^{**})_N anomaly, implying that select specimens were likely exposed to both reducing and oxidizing conditions at different timepoints either before or after burial. Investigations into the order of these redox events are still ongoing, but the abundance of reducing signatures in many specimens demonstrates the early-diagenetic environment was most likely reducing. The internal regions of bones were found to exhibit much more erratic and spatially heterogeneous patterns of elemental alteration than their respective external cortices. These collective findings independently support prior inferences that the HR Bonebed represents a partially reworked or short distance-transported mass death assemblage, and that this depositional history has imparted infrequent attritional signatures onto the mass death assemblage. To build on this work, we will next examine the trace element taphonomy of other sites in the surrounding area to understand the complete picture of the paleoenvironments

and diagenetic settings of the Lance Formation in northeastern Wyoming.

Funding Sources This research was supported by Southern Adventist University and Rowan University.

Technical Session 17: Fish (Saturday, November 5, 2022, 8:00 AM)

NEMATOPTYCHIUS: A PALEOZOIC PIKE IN PARTS

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The origin of crown Actinopterygii has been dated close to the Devonian-Carboniferous boundary; however, diversification into the wide range of shapes and sizes seen by the Viséan is not well-understood with the majority of available endoskeletal data restricted to small, fusiform species. Here we present the endoskeletal anatomy of NMS G.1974.23.9.2 *Nematoptychius greenocki* (Traquair 1875) from the Wardie Shales of Edinburgh, UK, and discuss implications on growth and constraint in early ray-finned fishes. *Nematoptychius* was a large pike-like predator briefly described in 1866 by Traquair, figured with jaw and palatoquadrate by Watson in 1928, and repeatedly referenced in later comparisons of actinopterygian dermal bones. High resolution microcomputed tomography (μ CT) reveals three-dimensionally preserved details of the braincase, visceral arches, and axial skeleton. These new morphological data are not only valuable for phylogenetic work on this notoriously poorly-resolved era of actinopterygian evolution, but also offer a new window into neurocranial adaptation for larger body size. Modern fishes that achieve extreme size undergo indeterminate growth. Skeletally, this is accomplished by outward propagation from persistent cartilaginous growth zones between independent centers of ossification. Most Paleozoic actinopterygian neurocrania are preserved as one cohesive unit, a signature of determinant growth and maturity. Though cranial fissures may persist, they are generally perichondrally ossified and not considered indicative of persistent growth centers. The braincase of *Nematoptychius*, on the other hand, is comprised of independent units with complete separation between the occipital, ethmoid, and left and right pterotic and sphenotic units. This delayed ossification of separate neurocranial components may represent a relaxed constraint on bodysize and/or an early step towards indeterminate growth. Comparative analysis of contemporaneous fishes *Elonichthys robisoni* and *Cheirodus crassus* complicate matters; while the slightly smaller piscivore *Elonichthys* has similarly discrete neurocranial components, the durophagous deep bodied *Cheirodus* does not, suggesting alternate approaches to increasing bodysize given different ecological constraints.

Funding Sources University of Chicago

Technical Session 15: Theropods (Saturday, November 5, 2022, 8:00 AM)

INSUFFICIENT EVIDENCE FOR MULTIPLE SPECIES OF *TYRANNOSAURUS* IN THE LATEST CRETACEOUS OF NORTH AMERICA: A COMMENT ON “THE TYRANT LIZARD KING, QUEEN AND EMPEROR: MULTIPLE LINES OF MORPHOLOGICAL AND STRATIGRAPHIC EVIDENCE SUPPORT SUBTLE EVOLUTION AND PROBABLE SPECIATION WITHIN THE NORTH AMERICAN GENUS *TYRANNOSAURUS*”

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The Late Cretaceous dinosaur *Tyrannosaurus rex* was recently split into three species based on the premise that variation in the *T. rex* hypodigm is exceptional, indicating cryptic species and “robust” and “gracile” morphs. The morphs are based on proportional ratios throughout the skeleton. The species are claimed to be stratigraphically separate, with an early robust species followed by robust and gracile descendants.

There are problems with the hypothesis: the taxon diagnoses are based on two features that overlap between the species; several skulls cannot be identified based on the diagnoses; proportional comparisons between *Tyrannosaurus* and other theropods are based on incomparable samples; the tooth data are problematic; the stratigraphic framework divides the Hell Creek Formation into thirds, without the stratigraphic position of each specimen, or independent age control showing the subdivisions are coeval over the entire geographic area; previous work found variation in *T. rex*, but it cannot be parsed into discrete categories.

We tested for “gracile” and “robust” morphs by analyzing their femoral and tooth ratios using agglomerative hierarchical clustering. The results found that each set of ratios are explained by one cluster, showing that dimorphism is not supported. We tested for exceptional variation of the femoral ratio of *Tyrannosaurus*; we calculated the mean intraspecific robusticity for 112 species of living birds and 4 nonavian

theropods. The results showed that the absolute variation in *Tyrannosaurus* is unexceptional and it does not indicate cryptic diversity. We conclude that “*T. regina*” and “*T. imperator*” are subjective junior synonyms of *T. rex*.

Colbert Prize Session

DOES SIZE REALLY MATTER? A TAPHONOMIC COMPARISON OF SMALL AND LARGE MAMMALS AT RANCHO LA BREA

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The Rancho La Brea (RLB) Tar Pits provides one of the largest and most unique collections of fossils from the late Pleistocene, including a wealth of large mammal fossils that have been a spotlight of research for over a century. However, smaller mammal species were often overlooked. One area of investigation previously explored exclusively on larger species is taphonomy, which encompasses the processes of bone fossilization from death to excavation. These processes include three categories at RLB: abrasion, weathering, and pit wear. Abrasion shows the erosion of bone surface due to the physical impact of sediment or water movement, weathering showcases how climate and soil conditions have a destructive effect on bone preservation, and pit wear demonstrates bone to bone interaction within a pit. In this study, the taphonomy of a variety of mid-sized or mesocarnivore (small to medium sized mammalian carnivores) specimens are quantified for the first time and compared to the taphonomy of larger specimens already collected from Pit 91 in RLB. Because surface area is greater on larger specimens, we expect that the incidence of taphonomy will be greater for the larger specimens in comparison to the mesocarnivores, though size is continuous, and the gradual effect of size on taphonomy may be possible to demonstrate. We find that mesocarnivore specimens generally score lower in measures of taphonomy, which appears to be unrelated to element completeness. There is a similar pattern of each type of taphonomy from largest to smallest taxa, while weathering is highest in the largest taxa and abrasion is generally similar except for the smallest mesocarnivores. This can be compared to other pits and to smaller herbivores to elucidate whether size alone explains these differences.

Funding Sources NSF EAR Sedimentary Geo & Paleobiology, Proposal 1758117

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

TURNOVER OF TERRESTRIAL HERBIVORES (DIPROTODONTIA: MARSUPIALIA) IN THE LATE OLIGOCENE, ETADUNNA FORMATION, SOUTH AUSTRALIA

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The lacustrine deposits of the Etadunna Formation, latest Oligocene (25 Ma–23.3 Ma), are divided into five faunal zones with a local fauna from each zone. The terrestrial herbivores are all diprotodontian marsupials, from either the koala/wombat clade, Vombatiformes, or the kangaroo clade, Macropodoidea.

The lowest faunal zone (Zone A=Minkina l.f.) are dominated by species with a selenodont dentition where the paracone and metacone have strong pre- and post-cristae producing a W-shaped pattern extending buccally from the main cusps to the margin of the stylar shelf. This pattern is present in the most robust and newest species of *Ilaria* (Ilariidae), a large terrestrial herbivore (~215 kg), plus the arboreal taxa, *Perikoala robusta* (koala) and, *Paljara* sp. nov. (ringtail possum). The other terrestrial herbivore is a new taxon of protoroid (rat kangaroo), which is semilophodont.

The next faunal zone (Zone B = Ditjimanka l.f.) has *Ilaria lawsoni* as the largest selenodont herbivore and a wynyardiid, *Muramura williamsi*, but here the upper molars are semilophate, whereas the lower molars are fully lophate. Two species of koala are present, *Perikoala palankarinnica* and *Madakoala wellsi*, plus a ringtail possum, *Pildra secundus*.

A marked change occurs at Zone C, (Ngapakaldi l.f.) and continues into Zones D and E, as all of the terrestrial herbivores now have lophodont or semilophodont dentitions. The vombatiform herbivores of Zone C are dominated by ngapakaldines, *Ngapakaldia tedfordi*, *N. bonythoni*, and *Pitikantia dailyi*, plus a new ngapakaldine taxon from Lake Pitikanta, all of which are fully lophodont. There is also a potoroid, *Purtia mosaicus* (semilophate) and two new macropodids (lophate), a *Nambaroo* sp. nov. and a new macropodid taxon.

This turnover of marsupial herbivores is also seen in the local faunas of the Tarkooloo Basin 250 km to the southeast, where the Pinpa l.f. (=Zone A) and Ericmas l.f. (=Zone B) have selenodont taxa and the Tarkooloo l.f. (=Zone D/E) taxa have mainly lophodont taxa. This latest Oligocene change in terrestrial herbivores coincides with the global warming trend at the end of the Oligocene and a corresponding sudden change in vegetation from more sclerophyllous leaf taxa in zones A and B to a more mesophyllous leaf taxa.

MUSEU NACIONAL/UFRJ AFTER THE FIRE: THE CHALLENGES OF DEVELOPING A PALEOVERTEBRATE EXHIBITION INTEGRATED IN A CIRCUIT OF NATURAL HISTORY

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Struck by a major fire in 2018 that devastated most of the collections and all items on display, the Museu Nacional/UFRJ, the first museum established in Brazil, is currently facing a great challenge: the rebuilding of new long-term exhibitions. This is an effort that involves different areas of expertise covered by the museum, coordinated by the Museum's Museology Section. Four circuits are being developed to account for the thematic complexity studied at the institution. The first, which involves the vertebrate paleontology collections and research, will be the *Universe and Life* Circuit, which will include different areas of natural sciences. This is a big change from the previous long-term exhibition, where skeletons of Pleistocene taxa (mainly elements of the Megafauna), the sauropod dinosaur *Maxakalisaurus topai*, a replica of the skull of a *T. rex*, several paleoartistic reconstructions and many fossils were not displayed in an integrated circuit. In terms of conceptual organization of paleovertebrate themes, the main problem lies in the organization of the processes, causes and consequences of the evolutionary adaptations observed in the paleontological record and balancing the fossil occurrences in Brazil within the global history of life. Among the problems that will be addressed include the need to reconcile main topics within the natural sciences to construct a single narrative and also the need to obtain new collections, since a large part of the museum's objects was lost in the fire.

Nonetheless, progress in developing the *Universe and Life* Circuit continues. The central concept is to present the Earth as a special planet, articulating themes of paleontology with geology, biology, and biological anthropology, in a space of 1445 square meters that will have approximately 4500 objects. To introduce paleontological themes to the museum's public, the circuit starts by showcasing collections and addressing themes from geology and biology, highlighting elements that are already part of the visitors everyday's life, and then ask the question "Where did all this diversity come from?". From there, the circuit dives into deep time to show how paleontologists build their knowledge based on the evidence left behind in the geological record, forming the module

History of life on Earth. Ten different moments in deep time that present major milestones are being selected with a special focus on Brazilian fossil occurrences.

Funding Sources Funding for this Project was provided by FAPERJ (#E-26/201.095/2022).

Technical Session 10: Soft Tissues & Taphonomy (Friday, November 4, 2022, 8:00 AM)

CONSTRAINT AND ADAPTATION IN THE PARAVIAN VISUAL SYSTEM: MINIATURIZATION AND THE FUNCTIONAL ANATOMY OF THE NICTITATING MEMBRANE APPARATUS

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The nictitating membrane apparatus, or third eyelid, of diapsids serves a key role in protecting the eyeball and maintaining the tear film critical for optical function. However, the muscle homologies of the nictitating apparatus in diapsids have not been established, and the apparatus has rarely been explored in the fossil record. Here, we studied the muscular anatomy of the nictitating apparatus across diapsids to identify osteological correlates, establish homologies, unify naming conventions for the muscles of the nictitating membrane, and reconstruct the nictitating apparatus in key fossil specimens. We used diceCT and spiceCT to differentially stain soft tissues of the orbit in microCT scans of 30 species of birds, 5 species of squamates, several specimens of American alligator, and 1 turtle specimen. Muscles and the tendon of the nictitating membrane were segmented in Avizo. Additional species were studied from the literature. Findings support homology between *M. retractor bulbi pars bursalis* (mRBb; formerly *M. bursalis*) of squamates, mRBb (formerly *M. retractor bulbi*) of turtles and crocodylians, and *M. bursalis membranae nictitantis* (mBMN; formerly *M. quadratus*) of birds. Homology is proposed between *M. retractor bulbi pars pyramidalis* (mRBp; formerly *M. retractor bulbi*) of squamates and *M. pyramidalis membranae nictitantis* (mPMN) of archelosaurs (turtles, crocodylians, and birds). In every diapsid group except birds, eyeball retraction, mediated by contraction of retractor bulbi, is required for the proper functioning of the nictitating membrane. Turtles and crocodylians retain eyeball retraction but also have pyramidalis (mPMN), which actuates the nictitating membrane. In birds, which also have pyramidalis, dramatic expansion of both the eyeballs and the brain (which encroaches into the orbit) coupled with small size (miniaturization) provides a constraint preventing eyeball retraction, necessitating a novel means of operating the nictitating membrane. We posit that evolution of pyramidalis in the archelosaurian ancestors of birds was one of the key factors that permitted birds to attain small sizes coupled with expanded brains and eyes and still maintain eye function with

a nictitating membrane. We reconstruct early avialans such as *Confuciusornis* and *Archaeopteryx* with the avian nictitating apparatus, mPMN + mBMN, whereas large-headed, relatively small-brained dinosaurs would have retained eyeball retraction, having mRBb and mPMN.

Funding Sources DGC—Johns Hopkins University School of Medicine, Ohio University Heritage College of Osteopathic Medicine (OUHCOM), LMW—NSF IOB-0517257, IOS-1050154, IOS-1456503; OUHCOM.

Virtual Posters

A NEW CROCODILE FROM THE EOCENE OF KUTCH BASIN, WESTERN INDIA

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The Kutch Basin in India is located in the western part of the country and has a near continuous sequence of highly fossiliferous marine sediments ranging from the middle Jurassic to recent. The Bartonian Harudi Formation is well known for its whale fossils but recently a skull of a saltwater crocodile has been recovered from the *Nummulites obtusus* bed of the Formation. The reconstructed skull is approximately 90 cm long and 25 cm wide at the middle (maximum width across the maxilla). Previously reported crocodiles from the Eocene of Kutch includes only one single species known as *Tomistoma tandoni* and fragments of indeterminate *Crocodylus*. The newly found specimen is not longirostrine, thus ruling out the possibility of it being a Tomistominae. The new specimen has a typical triangular skull shape with most of the middle and part of the posterior skull preserved along with teeth alveoli and some broken teeth. The teeth in the upper jaw are varying in size with no serrations along the edges. Some of the broken teeth preserved show a cylindrical shape which slightly tapers towards the top. A portion of the narrow frontals, wide maxillae, parts of the squamosals, parietals and upper temporal fenestrae are also preserved. The skull table shows elliptical upper temporal fenestrae and minimal ornamentation, whereas, the rest of the surface of the skull shows a much higher density of pock marked ornamentation. Only the right mandible is preserved which is slender with the anterior and posterior most portions broken but having at least 15 teeth alveoli preserved. The skull shows some similarities with “*Crocodylus*” *megarhinus* from the Eocene of Egypt, which is connected to the western part of India by the western arm of the Tethys. *C. megarhinus* is not a true *Crocodylus* and it is unlikely that the new specimen belongs to the crown genus either. The new discovery from India, thus, prompts the need to establish a new taxon which will help to bridge the gap in the study of crocodylian evolution, particularly in the Indo-African region.

Funding Sources Indian Statistical Institute, Kolkata, West Bengal, India

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

UNIQUELY PRESERVED NEW FAMILY OF TEMNOSPONDYL FAUNA RECOVERED FROM THE MIDDLE TRIASSIC OF INDIA

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An almost complete skull and associated mandibles of a new temnospondyl was collected from the Middle Triassic Anisian Denwa Formation, between the villages Meli and Sahavan of Satpura Gondwana basin, India. The skull has close similarities with *Vigilius wellesi* formerly known as *Hadrokkosaurus bradyi* from Geronimo fossil vertebrate quarry, Early Anisian Holbrook member of Moenkopi Formation, northeastern Arizona. The specimen is a nearly complete skull with associated mandibles. The skull looks very similar to *Vigilius* while the mandible bears certain similarities with *Hadrokkosaurus*. The mandible also looks very similar to some plagiosaurs particularly *Plagiosuchus pustuliferus* from Ladinian horizon of Gaildorf, Germany. However, it does not bear any striking similarity in characters with that of *Plagiosuchus*. A partial skull and associated left mandible of *Vanastega plurimidens*, collected from Anisian Burgersdorp Formation of the Upper Beaufort Group, Karoo Basin, South Africa also shares certain similarities with the new Indian taxon which has parabolic skull with large anterolateral orbits and lacks prominent tabular horns, lacrimal and intertemporal bones. It has a vaulted pterygoid but differs from other brachyopids except *Vigilius* and *Vanastega* by the presence of large orbits lower than most plagiosaurs, widely spaced nares, wide cultriform process of the parasphenoid and an emarginated cheek. The mandible is also unique in having an external mandibular fenestra at the labial side near the junction of surangular and articular that passes through the dentary almost up to the symphysis. It has an exceptionally long retroarticular process, a transverse trough behind the glenoid, a slit like opening between pre-articular and surangular, a shelf near the symphysis which is formed by dentary only and low posterior Meckelian opening at the sutural contact of postsplenial, pre-articular and articular. Some of these mandibular character states are also present in *Hadrokkosaurus*. The presence of the external mandibular fenestra is unique. The Indian taxon does not have pterygoid-vomer connection just like the brachyopids. This new taxon has been named named *Melisaurus aperta* after the village it was excavated in and *aperta* refers to the open nature of the skull margin due to the cheek emargination. After detailed phylogenetic analysis, a new family Hadrokkosauridae has been erected which includes *Meilisaurus aperta* and *Hadrokkosaurus bradyi*.

Funding Sources Ph.D. project funded by the Indian Statistical Institute under Ministry of Statistics and Program Implimentation, Govt. of India

Virtual Posters

HOW DOES ACRODONTY IMPACT ON THE TOOTH AND JAW MORPHOLOGY OF LIZARDS AND RHYNCHOCEPHALIANS?

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Lizards are the most speciose group of reptiles today, with over 7000 species and counting. Most lizards have a form of dental implantation known as pleurodonty, whereby the teeth sit upon a shelf (rather than in individual sockets, as in mammals and archosaurs) and are regularly replaced throughout the individual's lifetime. However, there is a group of iguanid lizards called the Acrodonta, that have acrodont implantation, whereby the teeth sit along the top of the jaw bones, to which they are fused and never replaced. This form of implantation is also shared by the now largely extinct sister group to lizards, the rhynchocephalians. Recent studies have suggested that acrodonty is linked to an increased bite force, here we investigated how acrodonty impacted on the tooth and cranial anatomy of these three groups. Our preliminary results indicate that both acrodont rhynchocephalians and Acrodonta have significantly fewer and larger teeth than pleurodont lizards, which could be an adaptation to withstand greater bite forces or to prolong tooth life in general by making them less resistant to breakage. We also discovered that rhynchocephalians have several significant differences in their tooth and cranial morphology to extant lizards; for example, they have yet fewer teeth on average and fewer cusps per tooth, and they are more likely to possess a 'premaxillary beak' formed by the fusion of the premaxillary teeth – a condition unknown outside acrodont taxa – more numerous palatal teeth and deeper, more robust chins (dentary symphysis). Together, this analysis forms a preliminary investigation into how structural anatomy and phylogeny control morphology in lizards and their relatives.

Funding Sources Tratman Bequest, Scholarship (funding Sofia Chambi-Trowell's PhD).

Technical Session 1: Dinosaurs (Wednesday, November 2, 2022, 8:00 AM)

INVESTIGATING EARLY BRANCHING SAUROPODOMORPH EMBRYONIC ANATOMY AND DEVELOPMENT

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At the end of the Triassic, Pangaea rifted, causing large-scaled environmental events that proved to be catastrophic for the planet's diversity. By this time, sauropodomorph dinosaurs had become the dominant herbivorous organisms in most terrestrial ecosystems and they remained unaffected by the event. Several factors play a role in a species' ability to thrive in post-extinction periods when reproductive pressure is increased. These include faster incubation periods, developmental plasticity, eggshell structure, and rapid growth rates. The study of reproductive biology in dinosaurs is hindered by the lack of embryonic material, as well as ontogenetic series of species. The early Jurassic sauropodomorph *Mussaurus patagonicus* presents an ideal study system for investigating some of these research questions as a single Patagonian site has yielded over 100 eggs and 80 skeletal specimens, representing an age series from embryo to adult. This taxon has already provided great insights into the behaviours and biology of basal sauropodomorph dinosaurs, with evidence suggesting soft-shelled eggs, herding, colonial nesting and ontogenetic locomotory shifts in posture. However, little of the embryonic skeletal material of *Mussaurus* has been included in these studies. Here we examine synchrotron radiation micro-computed tomography scans of two *Mussaurus* eggs and three sediment blocks containing embryonic remains. We study the level of ossification and compare it between the specimens. We also compare the anatomy of these *Mussaurus* fossils to older individuals of the taxon as well as to that of embryos of the closely related taxon *Massospondylus* in order to determine if diagnostic characters are present so early in early branching sauropodomorph development. We find that the skeletons within the *Mussaurus* eggs differ in their spatial distribution and ossification levels. We also observe morphological differences between *Mussaurus* and *Massospondylus* embryos, both cranially (e.g. in the maxilla, postorbital and squamosal) and postcranially (e.g. in the humeri and ilia).

Funding Sources Richard Gilder Graduate School, AMNH; European Synchrotron Radiation Facility; Paleontological Society; DSI-NRF GENUS; Palaeontological Scientific Trust

Technical Session 7: Paleogene Mammals & Primates & Carnivora (Thursday, November 3, 2022, 1:45 PM)

MULTI-GAPE ANGLE 3D BIOMECHANICAL MODELLING OF THE CAT-LIKE MANDIBLE REVEALS NUANCES OF SABERTOOTH FUNCTIONAL MORPHOLOGICAL EVOLUTION

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Throughout geological times, multiple clades converged in craniodental morphology with true cats (Felidae), notably nimravids and thylacosmilids. In those groups, the so-called sabre-tooth phenotypes is a textbook example of convergent evolution often interpreted as an adaptation for subduing large prey. This conventional framework implies homogenous ecologies for all sabre-toothed clades, failing to consider the functional differences between scimitar-toothed, dirk-toothed and 'mosaic' taxa, as well as the numerous species that convergently evolved smaller, conical canines. This simplified interpretation of the seemingly unique saber-tooth condition is reinforced by a reduced taxonomic sampling in some studies, often focusing on a couple of well-known, highly derived taxa or using highly simplified morphological models. Moreover, most biomechanical analyses focus on biting scenarios at small gapes (25 to 30°), a classical angle for modern carnivora that is however ill-suited to test for subduction of large prey by sabre-toothed taxa.

Here, we thoroughly analyze the biting biomechanics of sabre-toothed and non-sabre-toothed taxa by applying Finite Element Analyses (FEA) on the largest dataset ever assembled of cat-like placental mandible 3D models, under a variety of gape scenarios. We performed muscle-induced biting simulations on 17 different taxa, at three different angles (30°, 60° and 90°), and on multiple biting points to evaluate their adaptation to bite at large angle; the total number of biting simulations we performed reaches 1,074. While our results show a clear adaptation of extreme sabre-toothed taxa to bite at larger angles in terms of Von Mises stress, other performance variables (mechanical efficiency and adjusted strain energy) display surprising similarities between sabertoothed and non-sabertoothed forms between the different angles tested, highlighting a continuous rather than bipolar spectrum of hunting methods in cat-like carnivorans.

Funding Sources Fonds de la Recherche Scientifique F.R.S.–FNRS (FRIA grant number FRIA FC 36251) and F.R.S.–FNRS (MIS F.4511.19). NSF DBI 2128146

Technical Session 18: Birds (Saturday, November 5, 2022, 1:45 PM)

THE EARLY EVOLUTION OF CROWN BIRDS: PHYLOGENETIC AND MORPHOLOGICAL CASE STUDIES

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The origins and evolutionary history of crown-group birds are being increasingly well understood through recent advances in paleontology, developmental biology, and phylogenomics.

However, certain aspects of crown bird evolution, such as their timing of origin, the interrelationships among several major groups, and the affinities of many fossil taxa, remain persistently difficult to resolve. In part, these controversies may be attributable to the fact that efforts to leverage information from avian anatomy and the fossil record in the context of recent phylogenomic insights have been relatively limited in scope and number.

In this work, I performed several case studies integrating morphological data with findings from molecular phylogenetics to investigate specific problems in crown bird origins. For one of these case studies, I used combined molecular–morphological analyses to resolve the long-debated phylogenetic interrelationships within the avian clade Strisores, the results of which suggest a novel scenario for their morphological and ecological evolution. A second case study used a similar approach to investigate the phylogenetic position of the oldest well-corroborated fossil crown bird, *Asteriornis maastrichtensis*, placing it close to the phylogenetic root of the clade Galloanserae and highlighting its importance for understanding the evolutionary history of this group. A final case study focused on the assembly of a morphological dataset that comprehensively samples crown bird diversity and anatomy, starting with the avian pectoral girdle and forelimb skeleton. Using this dataset, I was able to identify potential sources of conflict among previous analyses as well as highlight potential morphological synapomorphies of major avian clades that had previously been recognized primarily only using molecular data.

Although the integration of information from avian morphology and fossils with recent insights from genetic studies has progressed relatively slowly, my results demonstrate that this avenue of research is both feasible and illuminating regarding the subject of avian evolution. It is hoped that future studies will build upon these findings to further clarify the origins of this diverse and charismatic group of organisms.

Funding Sources This project was funded by the Systematics Research Fund and a Paleontological Society Student Research Award.

Technical Session 6: Dinosaur Macroecology & Macroevolution (Thursday, November 3, 2022, 1:45 PM)

SHIFTS IN TROPHIC ARCHITECTURE AND ECOSPACE STABILITY DETERMINING SURVIVORSHIP AND EXTINCTION AT THE END-CRETACEOUS

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An explanation for why some species, such as non-avian dinosaurs, became extinct, whereas others, including mammals, survived the Cretaceous/Paleogene (K/Pg) mass extinction, 66 million years ago (Ma) is still debated. What were the mechanisms behind community restructuring and the emergence of new ecological opportunities after the K/Pg event, selectively driving extinction and survivorship patterns? Using Markov networks, ecological niche partitioning and Earth System models, we reconstructed disruptions in continental food web dynamics, simulating long-term trajectories in ecospace occupancy through the latest Cretaceous (83.6–66.0 Ma) and early Paleogene (66.0–61.6 Ma). This method uses partial correlation networks to represent how different trophic groups interact in a food web and builds on empirical spatial co-variations to explore dependencies between trophic groups. Our analyses are based on a spatiotemporally and taxonomically standardized dataset, comprising more than 1,600 fossil occurrences representing more than 470 genera of fish, salamanders, frogs, albanerpetontids, lizards, snakes, champsosaurs, turtles, crocodylians, dinosaurs (including birds), and mammals across the best sampled region for this interval, the Western Interior of North America. We explicitly tested whether: 1) shifts in food web architecture underwent major restructuring before and after the K/Pg transition, including whether some trophic guilds were more prone to these shifts than others; and 2) any of these changes were associated with fluctuations in the realized niche space, helping to explain survivorship and extinction patterns at the boundary. We find a shift in latest Cretaceous dinosaur faunas, as medium-sized species counterbalanced a loss of large herbivores, but that dinosaur niches were otherwise resilient and static until the K/Pg boundary. Smaller terrestrial vertebrates, including mammals, followed a consistent trajectory of increasing trophic impact and relaxation of ecological niche limits that began in the Cretaceous and continued after the extinction. Patterns of mammalian ecological radiation and niche restructuring indicate that these taxa did not simply proliferate after the extinction; rather, their earlier ecological diversification might have helped them survive the K/Pg event, whereas the static niche of dinosaurs might have contributed to their demise.

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

NEW TYRANNOSAUROID MATERIALS FROM THE UPPER CRETACEOUS EUTAW FORMATION OF MISSISSIPPI, USA

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Dinosaurs of North America's Cretaceous terrestrial ecosystems are predominantly known from highly fossiliferous formations in the western part of the continent. However, Laramidian ecosystems do not reflect the full scope of dinosaur evolution in North America during this interval. Throughout the majority of the Late Cretaceous, Appalachia and Laramidia were isolated, with each region likely following a unique evolutionary and ecological trajectory. However, the fossil record of Appalachia is often fragmentary and difficult to sample, and consequently less is known about theropods that lived in Appalachia, although there have been a number of recent discoveries and reinterpretations of historic findings. One of the Appalachian dinosaur clades recently subject to intensifying study is Tyrannosauroida. To date, only two valid taxa are described (*Dryptosaurus aquilunguis* and *Appalachiosaurus montgomeriensis*), although tyrannosauroid materials were first reported from Appalachia in the 19th century. Despite this, there are many other fragmentary specimens that offer important insight into the evolution of tyrannosaurs along the eastern flanks of the North American continent. Here we describe new materials from the Santonian Eutaw Formation of Mississippi, some of which (e.g., MT-I and pedal phalanges) have not been previously reported, adding new skeletal and morphological data on Appalachian tyrannosauroids. Pedal phalanges differ from contemporaneous theropod clades (e.g., Ornithomimosauria), supporting their tyrannosauroid affinities. Only one element (MT-IV) overlaps with known taxa. It exhibits a unique combination of features known in other Appalachian tyrannosaur taxa suggesting it represents a new taxon. These include a midshaft that is mediolaterally wider than craniocaudally tall with a flat caudal surface, an expanded distal end with a well-developed cranial aspect to the condyle, and a large medial ligament pit (similar to *Dryptosaurus aquilunguis*), and a laterally projecting distal end with a pronounced medial "buttressing" surface and teardrop-shaped articular facet for MT-III (similar to *Appalachiosaurus montgomeriensis*). Materials from this time interval, although fragmentary, fill a spatiotemporal gap in our understanding of North American tyrannosauroid diversity and are essential for reconstructing the evolutionary history of North American tyrannosauroids leading up to their rise as dominant mega-predators.

Virtual Posters

THE OLDEST CONFIRMED ARAGONITE IN THERMALLY ALTERED TURTLE EGGS OF THE

HASANDONG FORMATION (APTIAN–ALBIAN), SOUTH KOREA

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Turtles are unique vertebrates in that they lay aragonitic eggshells, unlike the calcitic eggshells of all other amniotes. Thus, detecting aragonite in turtle eggshells is a direct way to trace the unique reproductive biology of turtles. Before this study, the oldest unequivocal aragonite in turtle eggshells was from Late Cretaceous-aged (Campanian or earlier) eggs. In this study, we report preserved aragonite in Early Cretaceous (Aptian–Albian) turtle eggs from the Hasandong Formation of South Korea. We used electron backscatter diffraction (EBSD) and Raman spectroscopy to detect preserved aragonite. In addition, Raman spectra of the eggshells showed the presence of thermally altered organic matters. They yielded maximum paleogeotemperature estimations that reached nearly 260° Celsius during the taphonomic history. This means that aragonite can be preserved even in the presence of geothermal influence. Thus, earlier reports of 'fully-calcified' turtle fossil eggs may preserve very minor amount of aragonite, which is only detectable through advanced microscopic techniques. The correct understanding for aragonite preservation in fossil turtle eggshells will be important for correct understanding of reproductive biology of turtles, because there is another view that at least a few turtles laid fully calcitic eggshells. We suggest that the approaches presented in this study need to be applied to earlier reports of turtle eggshells in order to broaden understanding for paleobiology of turtles and taphonomy of turtle eggshells.

Funding Sources KRF Research Grant (2018R1D1A1B0704187214) to ISP and the International Partnership Program of Chinese Academy of Sciences (132311KYSB20180016) to SC.

Education & Outreach Poster Session

PALAEOPOEMS: HIGHLIGHTING POETRY AS SCIENCE COMMUNICATION IN A FREE ONLINE ARCHIVE

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Poetry is a unique tool for science communication and education. Poetry can include writing devices such as rhyme and humour that are often absent from academic writing,

allowing scientific content in poems to be read more quickly and understood more easily. Writing poems requires the poet to think about their topic of choice from a different perspective and choose their words carefully to conform to the structure of a poem. Palaeontology is an evocative field that benefits from poetic description. Even using rigorous data, creativity and imagination are required to reconstruct the character of ancient organisms, landscapes, and ecosystems. Contemplating the prehistoric past can be a deeply emotional experience, as extinct organisms, and the places they inhabited, are wondrous to imagine but can never be observed firsthand. Academic language leaves little room for expressions of emotion, in the pursuit that science remains as objective as possible, and so poetry has long-been an outlet for palaeontologists and enthusiasts to express themselves.

PalaeoPoems is a volunteer-run, non-profit digital archive featuring modern and historical poetry written by scientists and enthusiasts about palaeontology. The archive currently holds 27 poems written between the 1800s and present-day, covering a wide range of taxonomic groups, geological time periods, and palaeontological methods. Each poem in the PalaeoPoems archive is accompanied by a researched discussion of the scientific content that each poem is based on, as well as a short biography of the poem's author. As many of the scientific concepts in historical poems are outdated, historical poetry becomes a tool to track how people have thought about different scientific concepts over time, and how older ideas changed with new discoveries and research techniques. Each poem featured in the archive is accompanied by artwork from different guest artists, demonstrating the capacity of the poems to be used as educational resources and allowing readers to visually connect with the content of the poem. Finally, many poems are intended to be spoken aloud, and so those featured on PalaeoPoems all include voiceovers so people can hear how a poem was intended to be read while also providing a more accurate accessible audio medium than screen readers, which often cannot capture rhythm or pronounce taxonomic names.

Technical Session 19: Marine Mammals (Saturday, November 5, 2022, 1:45 PM)

FEEDING ECOLOGY AND FUNCTION IN EXTINCT TOOTHED WHALES, AS INFERRED FROM THE AREA OF ATTACHMENT FOR THE TEMPORALIS MUSCLE

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Diet and method of food processing influences temporalis muscle size in terrestrial mammals. However, quantitative analyses of temporalis muscle size in marine mammals, specifically extant and extinct whales, is still lacking. The

purpose of this study was to quantify the size of the area of attachment on the skull for the temporalis muscle, a useful proxy for muscle size. We examined 209 skulls of extant odontocete whale, and 20 skulls of fossil whales, including toothed mysticetes and archaeocete whales. We calculated a temporal fossa index (TFI) using measurements of the temporal fossa height and width for each skull, with body size removed by dividing each measurement by the occipital condyle breadth, a correlate for body size. We used ANOVA statistical tests to determine if differences in TFI were present, and if they correlated prey capture/prey processing technique (suction vs snap vs ram vs grip-and-tear feeding styles) in modern taxa. We found significant differences in the TFI between all feeding strategies except between grip-and-tear versus snap feeding. Differences in TFI values between these different feeding strategies likely reflects the relative importance of biting behavior and bite force in prey capture. When we compared TFI values from fossil whales with extant odontocetes, all archaeocetes, toothed mysticetes, and xenorhids had TFI values far above the range seen in extant odontocetes. High TFI values for *Coronodon* and *Aetiocetus* suggest that biting was still important for feeding, and indicate no specialization for suction feeding in these early mysticetes. *Semirostrum* had the lowest TFI value of any fossil whale included within this study, within the range exhibited by suction-feeding specialists. *Kentriodon* had a TFI within the range of ram-feeding odontocetes. *Notocetus* and *Argyrosetus* possessed a TFI comparable to modern snap-feeding river dolphins. *Zarhachis* had a very low TFI. This suggests that this hyper-longirostrine taxa, that relied on lateral rostral movements to stun prey, had little need for developed temporalis musculature. Preliminary findings of this study suggest that TFI could be a useful metric for interpretation of feeding ecology in extinct whales, and future work will focus on increasing the sample size of fossil taxa examined as well as expand upon the statistical analyses carried out in this study.

Technical Session 4: Paleobiogeography (Wednesday, November 2, 2022, 1:45 PM)

NEW INSIGHTS INTO ISLAND EVOLUTIONARY DYNAMICS FROM THE DODO (*RAPHUS CUCULLATUS*) AND THE SOLITAIRE (*PEZOPHAPS SOLITARIA*)

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Mauritius and Rodrigues, two neighboring islands of volcanic origin in the Mascarene archipelago, each supported an endemic flora and fauna that experienced rapid decline following the arrival of humans and the species they introduced. Although the extinction of Mascarene endemic vertebrates took place relatively recently, most are known predominantly or exclusively from fossil remains. Mauritius was the home of the dodo (*Raphus cucullatus*), a large flightless columbiform that went extinct in the late sixteen hundreds, less than a century after the discovery and settlement of the island by Dutch sailors. The demise of the dodo is one of the most iconic stories of human-induced extinction. Less well known is that Rodrigues also supported a large flightless columbiform that went extinct following human arrival, the solitaire (*Pezophaps solitaria*). The dodo and the solitaire are sister-taxa, but morphologically distinct. Cluster analysis of more than 950 fossil bones shows that, whereas the dodo exhibited relatively modest skeletal size sexual dimorphism (ca. 5%), similar to extant pigeons, the level of dimorphism observed in the hind limb skeleton of the solitaire was approximately 30%. Our analyses also show that the dodo experienced a rapid positive phenotypic shift in body size following human ecosystem disruption. In addition to substantial sexual size dimorphism, the solitaire exhibited adaptations for intraspecific combat such as a large carpal exostosis and historical accounts describe fierce combat between male birds. To explain the contrast in morphological development between the dodo and solitaire we examined the geological histories of the islands. We employed geophysical modeling to reconstruct the maximum coastal contraction rates of Mauritius and Rodrigues by sea level rise since the last ice age 26 ky ago. We found that coastal contraction rates led to major pulses of population density increase over generational time on Rodrigues but not Mauritius. We postulate that rapid sea level rise may have led to rapid overshoots in solitaire population density, increasing intraspecific competition. Our analyses suggest that contrasting tempos of natural environmental change for each island stood at the basis of divergent evolutionary and behavioral pathways in the dodo and the solitaire, and highlight the potential of the Mascarene fauna for informing our understanding of deep time ecosystem resilience and decline of insular populations.

Funding Sources National Geographic Society, National Science Foundation

Colbert Prize Session

PRELIMINARY ANALYSIS OF CLIMATIC CONDITIONS AND MAMMALIAN DIETARY INFERENCES ACROSS THE BRIDGERIAN NALMA

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Changes in climate can have significant impacts that alter existing community structure and result in novel ecosystems. Among the most significant climate shifts during the Cenozoic was the transition from the “hothouse” climate of the early Eocene to the “Doubthouse” of the middle to late Eocene (~46 to 34 Ma). The subsequent opening of the landscape in North America saw the expansion of certain mammal groups (e.g., ungulates) while others became extirpated (e.g., primates). The Bridgerian North American Land Mammal Age (NALMA) captures this transitional period, temporally positioned between the preceding hothouse Wasatchian and the cooler, dryer Uintan NALMAs. Although previous work has focused on the transition into or out of the Bridgerian, less work has been dedicated to understanding the climatic regime during the Bridgerian. The aim of this study is to unpack the climatic conditions during the Bridgerian to better understand climate's impact on mammalian faunal changes during this transition. Here we report on an exploratory study investigating mean annual temperature along with the ecology of two mammalian taxa from two different subzones of the Bridgerian using results from stable isotope analyses of tooth enamel. The fossils included in this study are from the Bridger Formation of southwestern Wyoming and represent three different localities from two stratigraphically adjacent subzones of the Bridgerian, the Blackforkian and younger TwinButtean. We sampled enamel from both upper and lower molars of two mammal genera, the terrestrial, archaic ungulate *Hyopsodus* and the arboreal, primate *Notharctus*. Interstitial carbonate was measured for $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ values using stable isotope mass spectrometry. Our results show relatively constant $\delta^{18}\text{O}$ values between the two intervals, reflecting consistent conditions throughout the Bridgerian. This supports previous work that indicates the cooling trend started at the onset of the Uintan. Moreover, our results show little to no difference in the $\delta^{13}\text{C}$ values for *Hyopsodus* and *Notharctus* despite them being interpreted as occupying different niches (terrestrial omnivore and arboreal folivore, respectively). The similar values also illustrate a lack of the Canopy Effect, as we would expect depleted $\delta^{13}\text{C}$ values for *Hyopsodus*. This project serves to fill the gap in our understanding of climatic changes throughout the Cenozoic and provide context for changes in mammalian community structure.

Technical Session 19: Marine Mammals (Saturday, November 5, 2022, 1:45 PM)

INSIGHT INTO ANCIENT SEAGRASS COMMUNITIES FROM THE DIVERSITY AND ABUNDANCE OF THE SIRENIAN FOSSIL RECORD

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Seagrasses are important primary producers in coastal areas, providing food and shelter for consumers in shallow, oligotrophic waters. Knowledge of their contribution to coastal areas in the past is limited because of their poor fossil

record, a problem that has been addressed by inferring their presence from the occurrence of fossil remains from organisms typically found in seagrass beds today. As an example, sirenians (manatees, dugongs, sea cows) are primary consumers of seagrasses today, and their fossils are commonly used as proxies for ancient seagrass meadows. Prior stable isotopic analysis of fossil remains and careful examination of sedimentological evidence support a close association between sirenians and seagrasses since the early Eocene. Here, we apply this proxy to examine how seagrass communities may have been impacted by major climatic events of the Paleogene.

Today, geographic ranges for extant sirenian species are restricted to subtropical waters where sea surface temperatures do not fall below 20°C. In the Paleogene, sea surface temperatures were much warmer than today and the latitudinal range of sirenians was significantly expanded. Relative to fossil occurrences for other marine mammals (i.e., cetaceans), sirenian fossils are abundant through most of the Eocene but show a significant decline in the late Paleogene that corresponds with major changes in ocean temperatures. Interestingly, this event is associated with the first appearance of the subfamily Dugonginae, a clade that showed morphological specialization for digging and consuming rhizomes within seagrass meadows. The timing of this specialization may reflect an increase in below-ground biomass of seagrasses as temperatures dropped and seasonality increased in coastal environments in the late Paleogene. Future study of these fossils and those of other organisms within seagrasses communities may yield additional insight into how these communities have evolved during the Cenozoic.

Funding Sources Funding was provided by a grant from the National Science Foundation (SGP EAR 0847413).

Virtual Posters

NEAR-SHORE MARINE VERTEBRATES OF THE SKELLEY LIMESTONE (CARBONIFEROUS: GZHELIAN)

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Three outcrops of the Gzhelian-aged Skelley Limestone (Casselman Formation, Conemaugh Group) were explored for vertebrate fossils in an effort to construct a better ecological framework for marine communities in the Late Pennsylvanian of southeastern Ohio (and adjacent regions). The Skelley Limestone represents the youngest marine limestone from the Pennsylvanian of Ohio. 20+ kg bulk samples of limestone were collected, acid treated, and sieved as part of this investigation and the resulting residues produced 14 distinct

near-shore vertebrate taxa. Osteichthyans were represented by an unknown paleonisciform and an unknown platysomid. Holocephalians were represented by symmoriforms, helodontiforms, cochliodontiforms, and petalodontiforms. Elasmobranch groups included ctenacanthiforms and euselachians which were represented by hybodontiforms, protacrodontiforms, and neoselachians. All osteichthyan taxa are reported from the Skelley Limestone for the first time. Furthermore, three chondrichthyan genera, *Ossianodus*, *Diablodontus*, and *Microklomax* are found outside their traditionally understood paleobiogeographic and biostratigraphic ranges. It is clear that marine units within the Conemaugh Group had high species richness and explorations into this diversity may generate further revelations in the paleobiogeography, biostratigraphy, and evolutionary history of a number of Paleozoic marine vertebrates.

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

CRANIAL AND POSTCRANIAL ONTOGENY OF THREE SPECIES OF *DIMETRODON* SHOWS SIZE DOES NOT CORRELATE WITH MATURITY

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Dimetrodon is a sphenacodontid with a large sample size, making it ideal for quantitatively recovering growth series. This study included 25 specimens (skulls, humeri, femora) and 73 characters; growth series were recovered using the new technology search in TNT.

The skull growth series for *D. limbatus* (TL=9, CI=1, RC=1) has two stages: (1) maxillary postcanine diastema present; and (2) maxillary step height ≥ 1.5 maxilla length. Congruence between maxilla length and maturity was tested using a Spearman rank correlation test (size rank data normal, Shapiro-Wilk $p=0.27$), which is not significant ($rS(0.05, 5)=0.94, p=0.06$).

The right humerus growth series of *D. loomisi* (TL=5, CI=1, RC=1) has two stages: (1) ossified supinator condyle, radial condyle, and ectepicondyle; and (2) ossified ectepicondyle. Low sample size ($n=2$) prevented a correlation test of length and maturity. The left humerus growth series of *D. loomisi* (TL=5, CI=1, RC=1) has two stages: (1) ossified radial condyle; and (2) humerus width to length ratio ≥ 1.8 . Correlation between length and maturity (size rank data normal, Shapiro-Wilk $p=0.27$) is not significant ($rS(0.05, 3)=0.94, p=0.06$).

The right humerus growth series of *D. booneorum* (TL=6, CI=0.83, RC=0.63) has four stages: (1) ossified supinator and radial condyles; (2) ossified ectepicondyle; (3) ossified entepicondyle; and (4) humerus width to length ratio ≥ 1.8 . Correlation between length and maturity (size rank data normal, Shapiro-Wilk $p=0.51$) is not significant ($rS(0.05, 6)=$

0.77, $p=0.07$). The left femur growth series of *D. limbatus* (TL=5, CI=1, RC=1) has three stages: (1) convex ends of the femur, ossified supracondylar process; (2): femur shaft width to length ratio $\geq 1:7$; and (3) femoral proximal to distal end width ratio $\geq 1:7$. Correlation between length and maturity (size rank data normal, Shapiro-Wilk $p=0.683$) is not significant ($rS(0.05, 3)=-0.33, p=0.67$).

The number of upper postcanine teeth and the ratio of the dentary height to maxillary length in *D. limbatus* are individually variable. The ossification sequences of the humeri and femora between the species are the same (ancestral for the clade). The humerus of the *D. loomisi* holotype is immature. Future work includes (1) expansion of the *Dimetrodon* data set; and (2) comparison of growth series of taxa that bracket *Dimetrodon* to uncover the ontogenetic underpinnings of the transition from basal to derived synapsids.

Funding Sources Research, Scholarship, and Creativity Committee (Student Grant)

Technical Session 16: Hoofed Mammals (Saturday, November 5, 2022, 8:00 AM)

ASSESSING MIGRATION IN PLEISTOCENE HERBIVORES AT RANCHO LA BREA

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The asphaltic seeps at Rancho La Brea (RLB) in California, USA, have accumulated and preserved organisms for over 50,000 years, including the herbivores *Bison antiquus*, *Equus occidentalis*, and *Camelops hesternus*. Based on serially sampled enamel isotopes, *B. antiquus* has been interpreted as a seasonal migrant at RLB, and *E. occidentalis* as a year-round inhabitant. Additionally, age profiles of *B. antiquus* show annual clusters of juveniles, interpreted as further evidence of migration. However, these age profiles could also be the result of increased summer seep activity, as asphalt becomes less viscous and entrapment events increase. We attempt to clarify age profiles by comparing tooth wear in *B. antiquus*, *E.*

occidentalis, and *C. hesternus*. Additionally, we investigated migration in *C. hesternus* using serially sampled enamel isotopes. We confirmed that *B. antiquus* age profiles show annual clusters of juveniles, while *E. occidentalis* age profiles are more continuous, supporting year round inhabitation in *B. antiquus*, but not *E. occidentalis*. Age profiles of *C. hesternus* differ from both *E. occidentalis* and *B. antiquus* with two peaks, corresponding to young juveniles ≤ 1 year in age and adults. The lack of individuals between these peaks in *C. hesternus* suggests that family groups similar to modern camelids were present at RLB. Serially sampled enamel isotopes for *C. hesternus* showed sinusoidal patterns in $\delta^{13}C$ and $\delta^{18}O$, with shifts in $\delta^{13}C$ between winter and summer months supporting migratory behavior. Our findings from tooth wear in conjunction with enamel isotopes indicate that age profiles can be a useful proxy for assessing migration patterns in extinct herbivores. *B. antiquus* appears to have been year-round residents at RLB, while *C. hesternus* and *E. occidentalis* exhibited seasonal migration into and out of the area.

Technical Session 14: Squamates & Turtles (Friday, November 4, 2022, 1:45 PM)

COMMUNITY STRUCTURE ANALYSIS OF TURTLES WITH APPLICATION TO THE EARLY PLEISTOCENE GRAY FOSSIL SITE OF NORTHEASTERN TENNESSEE

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Turtles are important components of ecosystems around the world, with diverse ecological niches and adaptations, and often represent substantial portions of fossil material recovered from excavations. However, there are few detailed studies of how turtle community structure reflects local environments, or how fossil turtles can be used to infer conditions of past ecosystems. This study examined over 130 modern turtle communities across the United States, with species at each site categorized based on their body size, habitat preference, and diet. Techniques of community structure analysis were used to examine how the taxonomic composition and attributes of turtles at a site reflect the environment, and to infer past conditions of the early Pliocene Gray Fossil Site (GFS) in northeastern Tennessee based on the 9 species of turtles preserved there. Discriminant function analyses (DFA) were conducted to determine how ecoregion or climate regimes could be classified based on the attributes of turtle communities. Bivariate correlations were used to identify associations between turtle communities and environmental parameters (temperature and precipitation). Results show taxonomic composition, habitat preference, body size, and diet all vary across turtle communities inhabiting different environments. DFA results indicate extant turtle community structure closely reflects environmental

conditions, with the ecoregion and climate regime of modern sites classified with greater than 80% accuracy. Strong bivariate correlations were found between variables and environmental parameters, with larger body size correlated with low latitudes, diversity of kinosternids and testudinids strongly correlated with warm conditions (higher minimum temperature) and low latitudes, and higher proportions of omnivores correlated with higher precipitation. These results suggest ancient turtle communities can be used to infer climate and habitat conditions of past ecosystems. Application to the GFS turtle community shows similarity to modern turtle communities of the southern Gulf Coast and subtropical southeastern United States, in particular the Texas-Louisiana Gulf Coastal Plains ecoregion. These findings are consistent with previous interpretations of the Pliocene GFS environment as warmer and wetter than the southern Appalachian climate of today, and demonstrate the utility of late Cenozoic fossil turtle assemblage data in determining past environmental conditions.

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

EARLY HEMPHILLIAN (LATE MIOCENE) SNAKES FROM THE TYNER FARM FOSSIL LOCALITY OF NORTH CENTRAL FLORIDA

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The late Miocene was a time of substantial climate change with associated shifts in habitats, which were heavily influenced by the time's placement between the Middle Miocene Extinction and the Great American Biotic Interchange. How these shifts influenced the evolution of various faunas—including snakes—across North America is an important question that has previously been passed over. Previous studies suggest a decline in boids and an increase in colubrids during the late Miocene, but these studies have been based on relatively few fossil sites which are largely west of the Mississippi River. Late Miocene fossil localities of Hemphillian age are rare, especially east of the Mississippi River, limiting our ability to assess faunal dynamics across the continent.

Tyner Farm fossil locality is an early Hemphillian (Hh1) site located in Alachua County, Florida. Since its discovery and establishment as an important paleontological site in 2001, numerous fossils from various mid- to large-sized animals have been identified and catalogued. Conversely, the microfauna has remained largely overlooked despite being among the richest and most diverse for any Hh1 fossil site. Thus, a detailed study of the Tyner Farm microvertebrates is necessary to help fill in the gaps in our understanding of the evolution and diversity of the smaller-bodied taxa from this time while providing important paleoecological information. Among the microvertebrates from the site, snake fossils are

the most abundant by a wide margin, particularly the vertebrae. These were sorted and identified to genus level through analysis by comparative morphology with modern specimens from the Florida Museum of Natural History herpetology collection. The snake taxa present are indicative of a terrestrial, lightly forested environment with members of the families Elapidae, Colubridae, Natricidae, and Dipsadidae being present. No boids were found, as the site was dominated by colubrids, and the taxa found are extant. Results show the first Hemphillian record of the coral snake (genus *Micrurus*), and provide important context regarding the relationship between boids and colubrids near the end of the Miocene.

Funding Sources NSF-CSBR

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

SUBTLE YET SIGNIFICANT CHANGES IN ENAMELOID MICROSTRUCTURE OF *ARCHAEOLAMNA KOPINGENSIS* OVER TIME

Cook, Todd D., Barmore, Lauren

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Archaeolamna kopingensis was a widespread Cretaceous lamniform shark with an extensive temporal range spanning from the Albian to the Maastrichtian. Utilizing acid etching and scanning electron microscopy, a histological examination of this species' dentition predictably revealed that the overall microstructure of the enameloid layer is similar to that of other neoselachians. The outer unit consists of a single crystallite enameloid of randomly oriented fluorapatite crystals, whereas the inner bundled crystallite enameloid unit contains distinct parallel bundled, tangled bundled, and radial bundled enameloid components. Surprisingly, a comparison of *A. kopingensis* enameloid from teeth recovered from different Cretaceous stages revealed subtle yet significant differences in the microstructure of this layer over time. Stratigraphically younger teeth have a layer of circumferentially oriented crystallite bundles situated just below the single crystallite enameloid on the labial crown face. This layer, which also contributes to the cutting edge microstructure, appears to be absent in stratigraphically older dentition. Consequently, differences in the enameloid observed in the dentition of *A. kopingensis* over time may suggest that is species actually represents multiple taxa.

Technical Session 2: Paleoecology (Wednesday, November 2, 2022, 8:00 AM)

THE EARLY CRETACEOUS PAJA FORMATION BIOTA IN COLOMBIA REVEALS A COMPLEX ECOLOGICAL NETWORK WITH HIGH PREDATOR

DIVERSITY SUPPORTED BY MULTIPLE MID-TROPHIC LEVELS

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Few fossil assemblages have been used to reconstruct ecological networks of trophic interactions. We present an ecological network for the marine Paja Biota with the intent to integrate it across Mesozoic marine ecosystems. The Paja Formation was deposited from the Hauterivian through to the Aptian in central Colombia. The Early Cretaceous was a transitional period in Earth's history and represents the recovery of the end Jurassic mass extinction, high eustatic sea levels, and high global temperatures - all factors that are expected to facilitate high levels of phyletic radiations. The formation preserves abundant marine invertebrates and vertebrates with good stratigraphic control. The invertebrate fauna consists of over one hundred species of ammonites and several bivalves and crabs. The vertebrate fauna includes massive short-necked plesiosaurs, large elasmosaurs, a teleosauroid crocodyliform, several species of ichthyosaurs, and sea turtles, and at least four morphotypes of actinopterygian fish and one shark. The taxonomic diversity of this palaeoecosystem hints at what this ecological network may look like. Several apex predators with ~10 m body lengths include the pliosaurs *Kronosaurus* (= *Monquirasaurus*) and *Sachicasaurus* and a teleosauroid. Mid-sized predators of >4 m include the pliosaurs *Acostasaurus* and *Stenorhynchosaurus* and the ichthyosaur *Kyhytysuka*. Another trophic level can be constructed from the large-bodied but small-headed elasmosaurs and stem sea turtles *Desmatochelys*, and *Leyvachelys*. The ecological network was computed incorporating interactions between all described and undescribed taxa based on criteria such as body size, tooth guild, cranial, and postcranial attributes. Although the fishes are relatively poorly known, the complex network constructed from the ammonites suggests an equally impressive network of fishes at these mid-trophic levels. Although this exercise reveals several potential confounding factors, such as taphonomic and sampling biases, our results reveal a complex Paja ecosystem network comprising more trophic levels than present in extant marine systems. The high diversity of predators is divided into multiple trophic levels and supported by an even greater diversity of intermediate trophic levels not comparable to any extinct marine system. This first attempt to compute a Mesozoic ecosystem network offers novel avenues to explore ecosystem evolution by integrating phylogenetic originations and extinctions.

Funding Sources NSERC CREATE 46283; STRI, Anders Found., 1923-Fund, Gregory-D., Jennifer-W. Johnson; Redpath M. Delise-Alison-2019; Sigma-Xi-GIAR-2019; QCBS-2019; SSB-2020; FRQNT-2021.

A NEW CROCODYLIAN FROM THE PALEOCENE FORT UNION FORMATION OF SOUTHEASTERN MONTANA

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We describe a new crocodylian taxon based on a partial skull from the Medicine Rocks 1 locality of the Paleocene Fort Union Formation of Montana. The posterior skull elements of YPM VPPU 16796, including the frontal, skull table, braincase and upper jaw joint are preserved in three dimensions with little to no matrix obscuring the skull anatomy of this small taxon. Although small, this specimen represents a mature individual as evidenced by the following preserved characteristics: skull elements are strongly sutured together; well-developed cranial ornamentation; a planar skull table when viewed from a posterior perspective; lateral margins of the skull table which trend anteromedially from the posterior edge of the squamosal; large, sub-circular supratemporal fenestrae; and a quadrate whose body is short but extends beyond the small occipital condyle. This morphologically unique taxon is diagnosed by the anterior orientation of the trigeminal foramen and lamina on the surface of the quadrate. Phylogenetic analysis recovers the taxon in equally parsimonious placements within Planocraniidae or Diplocynodontinae based partly on the orientation of the quadrate hemicondyle and the location of the foramen aereum. Precision and resolution among the phylogenetic hypotheses are reduced due to the incomplete nature of the specimen and few character states coded in the matrix. This new, phylogenetically distinct taxon adds to the known diversity of North American crocodylians that lived in the transitional period following the Cretaceous-Paleogene extinction.

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

PRELIMINARY RESULTS FROM A MULTIPROXY STUDY OF RUMINANT DIETARY ECOLOGY IN THE EARLY MIOCENE OF EASTERN AFRICA

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The Miocene in Africa is a period of substantial faunal turnover, coupled with climatic and environmental change. Recently, it has become clear that early Miocene fossil localities sample a mix of habitats, including some that were relatively open with a substantial grassy component. It is currently unclear how mammalian communities, which are composed of endemic afrotheres and increasing numbers of laurasiatherians, adapted to these novel habitats. We wanted to determine whether any mammals had begun to utilize these new habitats, by showing evidence for mixed feeding or grazing. Given their successful adaptation to grasslands in many parts of the world, we hypothesized that ruminants might be amongst the first lineages in eastern Africa to adapt to foraging on grasses. We tested our hypothesis using multiple dietary proxies.

We sampled all available ruminant molars from early Miocene fossil localities in Kenya and Uganda, collecting hypsodonty measurements, mesowear scores, microwear moulds, and isotopic dietary signatures from as many specimens as possible. Our total dataset at present is almost 400 individuals from sites spanning 21–17 Ma, including both pecoran ruminants and tragulids. Where possible, we have collected multiple dietary proxies from the same individuals.

Our results show no major shifts in diet throughout this period, no substantial differences between tragulid and pecoran ruminants, and no evidence for grazing. All mesowear data strongly indicate a largely browsing diet for both tragulids and pecorans. Microwear also reveals a strong browsing signal overall for all taxa. However, the high number of pits and prevalence of gouging, large pits, and relatively coarse scratch textures indicates a relatively dirty browsing signal seen typically in fruit browsing when exogenous grit coats food substances. In contrast, stable isotope results suggest some incorporation of C₄ grasses into the diet, with variation between sites and a possible trend towards higher δ¹³C values at younger sites. Since these dietary proxies each sample a different time scale, we expected varied results, although both microwear and isotope results are consistent with feeding in patchy habitats, matching habitat proxies from these same fossil sites. We plan to further refine our dataset by collecting additional isotope data, particularly from more of the teeth that were suitable for microwear and mesowear.

Funding Sources Natural Sciences and Engineering Research Council of Canada, the National Science Foundation, and the University of Calgary

Colbert Prize Session

DINOSAUR EATER: NEW INFORMATION ON THE ANATOMY AND PALEOECOLOGY OF THE GIGANTIC ALLIGATOROID *DEINOSUCHUS RIOGRANDENSIS* FROM THE UPPER CRETACEOUS AGUJA FORMATION OF WEST TEXAS

Cowgill-Warner, Ethan, LuJan, Andre

Texas Through Time, Hillsboro, Texas, United States

Deinosuchus riograndensis was an enormous alligatoroid known from the Late Cretaceous Aguja Formation of West Texas and Mexico. The type specimen, described in 1954, is very fragmentary. The taxon therefore remained poorly understood until a new collection of specimens were described in 2020. Here we describe a new adult specimen consisting of an articulated premental hemimandible including an articular, surangular, angular, partial splenial, coronoid and incomplete dentary as well as teeth and associated fragments. The new specimen reveals several morphological details of *D. riograndensis* for the first time. These include the presence of a deep, anteroposteriorly oriented groove on the medial side of the retroarticular process, the presence of a reduced articular foramen aerum, and a general lack of sculpturing on the lateral mandibular surface. Additionally, the external mandibular fenestra appears to be more reduced and triangular in shape than previously proposed, with the dentary forming almost the entirety of its dorsal margin. The foramen intermandibularis caudalis appears to be formed by the splenial and angular to the exclusion of the coronoid. Bones of a new large hadrosaurid specimen recently collected from the Aguja Formation exhibit deep, concave punctures which are consistent with the tooth morphology of *D. riograndensis*. This represents the most severe instance of dinosaur-eating behavior so far attributed to this crocodylomorph, further substantiating previous inferences that gigantism in this taxon may have been an adaptation for preying upon dinosaurs. All *Deinosuchus* feeding traces so far reported on Laramidian dinosaurs have been present only on hadrosaurids. Previous workers have used the lithology of dinosaur localities to document spatial niche partitioning between similarly common hadrosaurids and ceratopsids in the Late Cretaceous deposits of Western North America, finding the former to have preferred riverine settings and the latter to have preferred floodplains. The overrepresentation of *Deinosuchus* bite marks on hadrosaurids may represent a habitat preference for riverine environments by those dinosaurs. Alternatively, it may be the result of preference for hadrosaurids as prey by *D. riograndensis*, a higher mortality rate for attacks on hadrosaurids compared to other large dinosaurs, or a combination of these factors.

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

NEW MORRISON DINOSAUR BONEBED FROM THE SALT WASH MEMBER IN NORTHWESTERN COLORADO, USA

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Described here is a newly discovered multi-taxic bonebed within the Salt Wash Member of the Jurassic Morrison Formation in northwestern Colorado, USA. This locality has

yielded skeletal remains of at least twelve individual organisms including dinosaurs and other smaller vertebrate animals. The “Evil Tree Bonebed” contains both disarticulated and articulated specimens including a complete articulated dorsal vertebral sequence of a medium-sized ornithomimid. A series of articulated caudal vertebrae and associated elements have been preliminarily identified as *Brachiosaurus altithorax* and three articulated ribs along with a dorsal vertebra have been attributed to a diplodocid sauropod. The other identified species represented are *Stegosaurus*, *Torvosaurus*, and *Allosaurus*, along with a small-bodied theropod, a small crocodylian, fish, and plant material. All specimens collected are housed within the Colorado Northwestern Field Museum in Craig, Colorado. The fossiliferous bed is a green-gray, medium-grained sandstone with abundant rip-up clasts bounded by two bentonite layers. The taphonomy of the site provides unique insight into a possible damming event caused by the large-bodied *B. altithorax*. Articulated and disarticulated specimens within the homogeneous sandstone further provide an interesting study of mass deposition events and the effect large vertebrate bodies may have on the depositional environment. Ongoing stratigraphic work places the horizon within the Salt Wash Member of the Morrison Formation. Occurrences of field-identified genera within the Salt Wash Member of the Jurassic Morrison Formation have important implications which add to the fossil record which is poorly represented compared to the overlying Brushy Basin Member.

Funding Sources Funding was provided by the Murphy, Vaccaro, and Baciu families.

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

PRINTING, PAINTING, AND PRESENTING LOST WORLDS: ART AND 3D PRINTING AS AN INEXPENSIVE TOOL FOR INCREASING THE ACCESSIBILITY OF VERTEBRATE FOSSILS IN EXHIBITIONS AND CLASSROOMS

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One of the prominent issues paleontology faces in regard to K-12 education and public exhibitions is specimen-accessibility. The recent advent of 3D printing technology has allowed for major breakthroughs in the accessibility of geological, biological, and paleontological resources for researchers and students. Though 3D prints possess much educational potential, they often do not resemble actual fossils, due to the “pixelated” nature of the printing material. By using scientific illustration and artistic techniques used in entertainment production design (e.g. epoxying, undercoating, washing, dry-

brushing, etc.) on 3D prints, we have created “hybrid” specimens that transform the prints from layered polygons to realistic replicas and effective educational resources. This hybrid approach combines the accuracy of this resource (at varying scales) with the realism of traditional molds and casts (yet in a cheaper and more environmentally friendly format). These replicas and reconstructions, all printed, prepared, and painted by undergraduate students, have served as vital tools for outreach, public engagement, museum exhibitions, and student projects. This enhances our outreach to thousands of K-12 students, many from rural communities, hours from natural history exhibits or fossiliferous strata. In addition to external outreach, we also use 3D printing in 1000-level and 3000-level courses to provide access to otherwise challenging specimens (e.g. foraminifera), and as part of a paleontological methods course. Additionally, our student interns can use 3D printing to generate both permanent exhibits and traveling interactive displays, which are geared toward specific state standards for K-12 education. With free online resources, students can recreate rare specimens from across the globe in mere hours. Utilizing this technology, we have created dozens of large- and small-scale replicas, exhibitions, and multimedia tools for scientific outreach and display. These applications range from a full-sized replica of a *Tyrannosaurus rex* skull plaque mount, now on display in our McKinney Geology Teaching Museum, to diverse interactives using scale models. The scalability of 3D technology had allowed our geoscience department to print scale replicas of famous specimens such as the holotype of *Tiktaalik roseae*, *Syntomiprosopus sucherorum*, early cetaceans, *Majungasaurus crenatissimus*, *Coelophysis bauri*, *Bison latriformis*, metoposaurs, and conodont teeth, to name a few.

Funding Sources Appalachian State University Office of Student Research and the Department of Geological and Environmental Sciences

Technical Session 7: Paleogene Mammals & Primates & Carnivora (Thursday, November 3, 2022, 1:45 PM)

AUDITORY REGION OF PALEOCENE ZANYCTERIS PALEOCENUS AND THE RELATIONSHIP OF PICRODONTIDS TO PLESIADAPIFORMS

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Plesiadapiforms, an assemblage of Paleogene mammals, are often supported by phylogenetic analyses as stem primates or stem primatomorphans (Primates + Dermoptera). The Picrodontidae from the middle Paleocene of North America have been allied with various mammalian groups but are now generally considered close relatives of palaeothonid and

paromomyid plesiadapiforms due to proposed dental synapomorphies, such as upper molars with a strong postprotocingulum and an expanded distolingual basin. The picrodontid fossil record is exclusively dental, except for a palate and basicranium of *Zanycteris paleocenus* (AMNH 17180), which were embedded in plaster following their discovery over a century ago. Through micro-CT scanning we were able to confirm the association of the palate and basicranium and visualize previously unknown anatomy of the petrosal and ectotympanic bones. The petrosals of *Z. paleocenus* possess a unique combination of features including a “dish-like” expansion formed by a large continuous epitympanic wing and rostral tympanic process, and a caudal tympanic process located posterior to the fenestra cochleae. While fragmentary, these features were unlikely to have formed or supported a bulla of either petrosal, entotympanic, or ectotympanic elements. Unlike that of all non-microsopid plesiadapiforms, the petrosal of *Z. paleocenus* lacks a posterior septum that “shields” the fenestra cochleae and lacks additional septa originating from the promontorium. Like Paleogene microsopids, nyctitheriids, and apatemyids, *Z. paleocenus* possesses an open sulcus for the facial nerve and a posteromedial entrance for an unreduced internal carotid artery, which are features considered primitive for eutherians. *Z. paleocenus* has a fusiform ectotympanic and differs from that of all described plesiadapiform crania in lacking “bony struts” for attachment to a bullar wall. Our observations of the petrosal and ectotympanic either suggest that picrodontids are plesiadapiforms that possess a unique combination of a primitive auditory region and a highly derived dentition or that picrodontids might not be plesiadapiforms after all.

Funding Sources This study was funded by NSF grant DEB-1456826 and 1654949 and a PSC CUNY Award jointly funded by The Professional Staff Congress and The City University of New York

Technical Session 2: Paleoecology (Wednesday, November 2, 2022, 8:00 AM)

WHAT CAN HIPPO ISOTOPES TELL US ABOUT PAST DISTRIBUTION OF C₄ GRASSY BIOMES ON MADAGASCAR?

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Expansive C₄ grassy biomes currently cover much of central, western, and northern Madagascar, and phylogenetic work suggests that many of the endemic and native grass lineages have been present on Madagascar since the late Miocene. We used stable carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$) isotopes in hippo bone collagen to reconstruct spatial and temporal variation in hippo diet and preferred habitat, and examined the implications of these data for the past distribution of C₄ grassy

biomes on Madagascar. If grassy biomes were maintained by natural fires and grazing in the past, then large herbivores like Malagasy pygmy hippopotamuses (*Hippopotamus* spp.) should have regularly consumed C₄ grasses, and we would expect them to have a C₄ carbon isotope signal. In contrast, if rainfall was the primary driver of past vegetation on Madagascar, and Malagasy hippos were opportunistic mixed feeders (like pygmy hippopotamuses in mainland Africa), then we would expect them to have consumed more C₃ plants in wetter, forested habitats, and more C₄ grasses in drier, more open habitats. Furthermore, if extensive C₄ grassy biomes are the result of human-induced fires and the introduction of domesticated grazing ungulates near the end of the first millennium CE, then Madagascar’s forests would have been more extensive in the past than they are today, and hippopotamuses would have predominantly exploited C₃ plants. Overall, the data support our prediction that hippos ate more grasses in drier regions. However, we observed a negative relationship between hippo $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values along the southwest coast and at high elevation sites in central Madagascar. This likely reflects consumption of C₄ sedges, but also possibly some C₄ grasses, in wet microhabitats. We found no support for widespread consumption of C₄ plants by hippos anywhere on the island. Hippo $\delta^{13}\text{C}$ values suggest little to moderate consumption of C₄ foods, and this is especially true for regions that are blanketed by C₄ grasses today. There is also no evidence for dedicated C₄ grazing by other native vertebrates. Yet, many Malagasy grasses have adaptations for grazing. We suspect that these adaptations are ancient and accompanied grasses when they spread to Madagascar in the late Miocene. Malagasy grasses were thus pre-adapted to grazing, and grassy biomes likely expanded only after the introduction of true grazers like cows.

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Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

TESTING HYPOTHESES REGARDING SUPER-PRECOCIAL DEVELOPMENT IN ENANTIORNITHES

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Since their origin, birds have been enormously successful, quickly diversifying into numerous lineages and encompassing significant ecological diversity. While their non-avian dinosaurian relatives appear to be predominantly precocial, developmental patterns in extant bird taxa vary along a spectrum from altricial to precocial, accompanied by

marked differences in their early physiology, anatomy, and behavior. At one end of the spectrum, altricial hatchlings enter the world highly vulnerable: naked, blind, and entirely reliant on their parents. At the other end, precocial birds hatch covered in natal down with well-developed hindlimbs that allow them to forage independently, relying on their parents primarily for protection. An exception are the super-precocial Megapodidae, the so-called mound-builders, which can fly after emerging from the mound and receive no post-hatching parental care. The most abundant and successful clade of Mesozoic birds is the Enantiornithes, a group of predominantly arboreal birds that dominated terrestrial avifaunas throughout the Cretaceous. All available information suggests these birds were developmentally highly precocial, hatching fully independent and flight capable. This evidence includes highly ossified and or fledged embryos and hatchlings with fully developed remiges. To test the hypothesis that enantiornithine hatchlings were flight capable, we quantify growth trajectories in enantiornithines and compare them to ontogenetic changes in extant birds across the altricial-precocial developmental spectrum. This data supports previous interpretations that enantiornithines were precocial.

Technical Session 6: Dinosaur Macroecology & Macroevolution (Thursday, November 3, 2022, 1:45 PM)

USING BIOGEOCHEMICAL PROXIES TO TEST HYPOTHESES OF FOOD WEB STRUCTURE AND NICHE PARTITIONING IN FLOODPLAIN ECOSYSTEMS OF THE CAMPANIAN BELLY RIVER GROUP OF CANADA

Cullen, Thomas, Zhang, Shuangquan, Maddin, Hillary, Cousins, Brian

Earth Sciences, Carleton University, Ottawa, Ontario, Canada

The Late Cretaceous floodplain paleocommunities of North America preserve a rich record of biodiversity, and studies of these systems suggest that many species occupied relatively narrow biogeographic ranges when compared to their extant equivalents. How co-occurring taxa in these systems partitioned their niches and structured their communities can be difficult to determine from direct examinations of fossils alone, which in some cases have led to a variety of hypotheses concerning diets and habitat use patterns. Following similar applications in modern and extinct taxa, we employed a suite of biogeochemical proxies of habitat use/breadth, environmental associations, and diet and trophic position, in order to reconstruct the structure of this community and test previous ecological hypotheses in this system.

We measured and compared the $\delta^{13}\text{C}$, $\delta^{18}\text{O}$, and $^{87}\text{Sr}/^{86}\text{Sr}$ compositions, as well as elemental ratios (primarily Sr/Ca, Ba/Ca, Mg/Ca, Pb/Ca), preserved in the bioapatite tissues of a range of co-occurring taxa ($N_{\text{taxa}}=18$), sampled from a spatiotemporally-constrained bonebed deposit in the Oldman Formation of Alberta. We also performed tests to assess the

preservation of original signals and potential diagenetic overprinting.

Among the sampled large ornithischians, we find that ceratopsids and ankylosaurs preserved distinct Sr/Ca and Ba/Ca ratios consistent with differences in consumed dietary plants, while hadrosaurs possessed elemental ratios overlapping with both, but $^{87}\text{Sr}/^{86}\text{Sr}$ ranges distinct from either, indicative of differences in both habitat use/breadth and feeding-height. In contrast to the ornithischians, the sampled tyrannosaurids, dromaeosaurids, crocodylians, and varanoids all preserve relatively low elemental ratios, consistent with their hypothesized carnivorous diets. The dromaeosaurids *Saurornitholestes* and *Dromaeosaurus* also preserved distinct $^{87}\text{Sr}/^{86}\text{Sr}$ and Sr/Ca ranges, suggestive of dietary and habitat partitioning. Troodontids, which have been variably hypothesized as either carnivorous, omnivorous, or herbivorous due to their unusual dentition, were analyzed using a Bayesian mixing model approach to estimate diet and recovered as omnivores, consuming a mixture of plants and small vertebrates. Continued analyses using these proxies, in concert with other sources of data, should allow for robust reconstructions of ecological structure, and the testing of temporal patterns of community dynamics and responses to climatic change.

Funding Sources Natural Sciences and Engineering Research Council of Canada (NSERC)

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

A SECOND INDIVIDUAL OF DROMAEOSAURID SHRI DEVI FROM THE LATE CRETACEOUS BARUUNGOYOT FORMATION OF MONGOLIA

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The Upper Cretaceous sediments of the Gobi Desert yielded several dromaeosaurid taxa. Three species have been described from the Baruungoyot Formation, namely velociraptorines *Shri devi* and *Kuru kulla*, and halszkaraptorine *Hulsanpes perlei*, all of which are known from the holotypes only. Here, I report another dromaeosaurid specimen collected from the Baruungoyot strata of the Khulsan site, containing a partial skull in close association with a left hind limb. The specimen was discovered in 1971 and originally labelled as *Velociraptor mongoliensis*, a taxon known only from the sediments of the Djadokhta Formation. The material can be referred to as *Shri devi* based on the apomorphic morphology of the pes, including the highly hypertrophied ungual of the second digit, the proximally wide metatarsal II, and the laterally placed tubercle on the anterior surface of the metatarsal III. In addition, the specimen contains a skull that was not preserved in the holotype. The anatomy of the cranium confirms the close relationship

between *Shri devi* and *Velociraptor mongoliensis*. Furthermore, it provides additional diagnostic features that distinguish *S. devi* from other dromaeosaurids, including a short antorbital fenestra, a relatively posterior position of the last maxillary tooth, and a deep mandible posteriorly.

Funding Sources This project is supported by the National Science Centre, Poland, grant no. 2020/36/T/NZ8/00395.

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

A REEVALUATION OF THE PHYLOGENETIC RELATIONSHIPS OF THE CONTROVERSIAL CENTRAL ASIAN SAUROPOD *DZCHARATITANIS KINGI*

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Asian sauropod faunas are notable for the presence of apparently endemic clades such as Mamenchisauridae and Euhelopodidae and the putative absence of otherwise widespread clades such as Diplodocoidea and Brachiosauridae. One challenge to this pattern of endemism comes in the form of *Dzcharatitanis kingi*, a taxon represented by a single anterior caudal vertebra from the Turonian Bissekty Formation of Uzbekistan, which was recently described as the first known Asian rebbachisaurid. Shortly after *Dzcharatitanis* was described, its rebbachisaurid affinities were challenged, and it was reinterpreted as belonging to Lognkosauria, a clade whose only definitive records are from South America.

However, previous phylogenetic analyses of *Dzcharatitanis* have not included *Baotianmansaurus* or *Dongyangosaurus*, two near-contemporary Asian sauropods that the *Dzcharatitanis* holotype has previously been noted to resemble. I added *Dzcharatitanis* to two phylogenetic datasets that include these taxa. The first is based on that of Poropat et al. 2021 with several modifications, including two new characters and the addition of *Sonidosaurus*, *Tambatitanis*, and *Abdarainurus*. The second is an in-progress novel dataset of general sauropod relationships with 125 taxa and 486 characters.

Preliminary analyses of both datasets recover *Dzcharatitanis* as a non-eutitanosaur somphospondylan, in a clade of Asian sauropods that includes *Baotianmansaurus*, *Erketu*, *Huabeisaurus*, *Sonidosaurus*, and *Tambatitanis*, as well as potentially *Abdarainurus*, *Dongyangosaurus*, and various other Asian taxa. The name Huabeisauridae is available for this clade, which unites several taxa previously viewed as having euhelopodid or opisthocoelicaudiine affinities. Many of *Dzcharatitanis*'s unusual characters are present in some other huabeisaurids, such as slight opisthocoely, subtle "triangular lateral processes", a dorsoventrally elongate neural canal, and postzygapophyseal processes, though the

distribution of these characters within Huabeisauridae is complex.

On both anatomical and biogeographic grounds, *Dzcharatitanis* is unlikely to be either a rebbachisaurid or lognkosaur. Instead, it appears to belong to Huabeisauridae, a previously largely unrecognized clade that may have been one of the major lineages of Asian sauropods during the middle to late Cretaceous.

Technical Session 6: Dinosaur Macroecology & Macroevolution (Thursday, November 3, 2022, 1:45 PM)

THE EVOLUTION OF GIGANTISM AND MINIATURIZATION IN THEROPOD DINOSAURS

D'Emic, Michael D.¹, O'Connor, Patrick M.², Sombath, Riley S.², Cerda, Ignacio³, Pascucci, Thomas¹, Varricchio, David⁴, Pol, Diego⁵, Dave, Anjali¹, Coria, Rodolfo⁶, Curry Rogers, Kristina⁷

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We present a large-scale phylogenetic comparative analysis examining developmental strategies underlying the evolution of body size, focusing on non-avian theropod dinosaurs. We assembled an expansive histological and body mass dataset of over 40 non-avian theropod dinosaurs, measuring nearly 500 annual cortical growth marks from about 80 skeletal elements. Growth mark circumferences were used to estimate annual growth rates and model growth curves. We used ancestral state reconstruction to map the evolution of body size and growth rates onto a time-calibrated phylogeny and project growth rate and body mass onto a phylomorphospace. Novel histological samples for ten non-avian theropods reveal an extreme range of growth strategies across their body size spectrum: some of the largest theropods grew as quickly as do large extant mammals, while others grew slower than extant crocodylians. The smallest theropods exhibit a similarly large range of growth rates. Phylogenetically informed regression reveals no relationship between body mass and growth rate, nor is there a significant trend through geologic time for Theropoda as a whole or its constituent clades. Reconstructed growth rate along the stem from the ancestral theropod to the ancestral maniraptoran shows a consistent decrease in growth rates, paralleling their sustained miniaturization. Paravians decouple this trend, further decreasing body mass but increasing growth rate. Our results align with clade-specific, morphology-based inferences of heterochrony in several theropod clades, including peramorphosis in carcharodontosaurids and paedomorphosis in paravians.

Funding Sources US National Science Foundation (EAR1525915).

Virtual Posters

ANATOMICAL PECULIARITIES OF THE GIANT PTEROSAUR *THANATOSDRAKON AMARU* (AZHDARCHIDAE, PTERODACTYLOIDEA) FROM UPPER CRETACEOUS DEPOSITS OF MENDOZA, ARGENTINA

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The largest South American pterosaur, *Thanatosdrakon amaru*, represents an excellent case study to analyze the importance of expanding phylogenetic matrices with appendicular characters. Several phylogenetic results recover *Thanatosdrakon* deeply nested in the Azhdarchidae clade, as it presents numerous characters in the humeri that are decisive in achieving these results. However, *Thanatosdrakon* presents unique characters that evidence a greater diversity in the classic morphologies described for azhdarchids. The preserved axial sequence shows a remarkable development of neural arches and very reduced vertebral centers. This structure is maintained from the posterior cervical vertebra to the dorsosacral vertebrae. The proximal syncarpal has a morphology similar to those described for azhdarchids, however, it presents a developed posterodistal process. Finally, the characteristics of the wing phalanges are singular, lacking the ventral ridge observed in many azhdarchids. Preliminary histological analyses indicate that the smallest specimen (UNCUYO-LD 307) is a juvenile-subadult, and these characteristics could be due, in part, to the ontogenetic stage of the specimen. In azhdarchids, the characters related to the skull and middle cervical vertebrae are crucial for phylogenetic resolutions. Taxa lacking these structures are shown to be unstable in topologies. Detailed characterizations on other elements, such as the humerus, have partly solved these problems. However, there is a need to expand the number of characters in appendicular elements that would allow improved resolutions in less inclusive clades.

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Preparators' Session (Thursday, November 3, 2022, 8:00 AM)

EXAMINING DATA COLLECTION, ARCHIVING PROTOCOLS, AND DATA ACCESSIBILITY IN FOSSIL PREPARATION LABS

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Over the past five years, improvements to the Sternberg Museum of Natural History paleontology department have resulted in a renovated fossil preparation lab and a new database for specimen data storage. Collection staff also developed workflows to assist staff, students, and volunteers with data and metadata collection and archiving. However, these improvements have highlighted areas where we are still struggling with data acquisition, transfer, and archiving. One such area in need of improvement is the transfer of preparation-related information from the prep lab to the collections database. The purpose of this study is to bridge the gap in communication to ensure all data collected in preparation labs are properly archived and made available to those who need it. To find ways to improve our protocols, we constructed and sent a survey to various institutions across the international paleontology community to determine how others handled prep data collection and transfer, with the hope that we could use already established best practices to mitigate our issues. The survey included questions that address what data are collected during fossil preparation, how data are collected, how data are stored, who can access data, and improvements needed in current protocols. Survey results show that the Sternberg Museum is not alone in our struggle with lack of standard protocol for data communication between the prep lab and collections. Specifically, survey responses illuminate gaps in data collection and archiving protocols that cause data to be uncollected, lost, or unarchived. Results also show that a large portion of institutions do not have a formal workflow or data collection protocol in place to ensure that data collected in the preparation lab are archived properly, resulting in confusion or data being lost. Almost all institutions surveyed agreed that there is room for improvement in their current processes where data are being lost or uncollected. These results are significant because it is important to know the complete history of a fossil, such as which chemicals have been applied or any marks made to the specimen during preparation, prior to long-term storage in collections. Ultimately, we hope to use the information gathered in this study in collaboration with other institutions to create a best practices protocol that can be implemented in fossil preparation labs and collections regardless of institution size.

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

SIGNIFICANT VERTEBRATE FOSSIL LOCALITIES DISCOVERED DURING PALEONTOLOGICAL RESOURCE INVENTORY OF THE TRIASSIC MOENKOPI AND CHINLE FORMATIONS AT CANYONLANDS NATIONAL PARK

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PALEOGENE HORNERSTOWN FORMATION OF NEW JERSEY

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The Jean and Ric Edelman Fossil Park (formerly the Inversand site) located in Mantua Township, New Jersey, possesses a diverse assemblage of Cretaceous and Paleogene marine fauna. The majority of these fossils come from a bonebed known as the Main Fossiliferous Layer (MFL) at the base of the K/Pg Hornerstown Formation. Here we describe a rare and unusual tarsometatarsus (RU-EFP-02871) from the MFL. While only the distal half is preserved, the bone is quite small, measuring a total length of 10.32 mm with a distal width of 2.7 mm, and a shaft width of 1.07 mm. Avian fossils in NJ are rare with only 20 described specimens, most of which are isolated partial bones. Only one other tarsometatarsus has been described from the MFL and was assigned to *Telmatornis priscus*, although the holotype does not include this skeletal element. The diminutive size of our specimen and a few other morphological differences suggest that RU-EFP-02871 represents a different taxon. Morphologically, our specimen bears at least a superficial resemblance to the tarsometatarsi of extant grebes and other foot-propelled diving birds with its large distal vascular foramen and strongly retracted metatarsal II. However, further phylogenetic analysis is needed. As the MFL is thought to represent a mass-death assemblage related to the K/Pg impact event, this specimen may also provide further insights into avian diversity, survival, and extinction at the end of the Cretaceous.

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

A NEO - PALEONTOLOGICAL PERSPECTIVE ON THE MORPHOLOGICAL DIVERSIFICATION OF CARANGARIAN FISHES (JACKS, FLATFISHES, BILLFISHES, AND ALLIES)

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With lineages as anatomically and ecologically disparate as flatfishes, remoras, billfishes, and jacks, the Cenozoic spiny-rayed fish clade Carangaria represents an intriguing system for studying patterns of morphological change. Past studies of patterns of body shape evolution in carangarians have employed two different approaches. The first quantifies fluctuating levels of disparity over time using fossil species, without a consideration of phylogenetic relationships. The second fits explicit models of trait evolution using data for living species and time-calibrated molecular phylogeny. Both offer incomplete perspectives on patterns of diversification. Here we combine neontological and paleontological approaches to test past hypotheses about shape evolution in carangarian fishes. We selected 16 well-preserved fossil

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Through a systematic program of paleontological resource inventory and monitoring, the National Park Service (NPS) has been at the forefront of paleontological resource management on public lands. The Utah Geological Survey has partnered with the NPS for the past twenty years to inventory and monitor paleontological resources in the national parks of Utah that contain significant vertebrate fossils. These inventories have focused on Mesozoic rocks, especially the Triassic Chinle and Moenkopi Formations, because of the extensive outcrop exposure in the parks and high potential for scientifically significant vertebrate fossils. Although many parks have completed baseline paleontological resource inventories and more targeted follow-up fossil surveys, the fossil resources of Canyonlands National Park (CANY) have remained virtually unknown. In 2020, we began a survey of paleontological resources in CANY, focusing our efforts on the Early Triassic Moenkopi and Late Triassic Chinle Formations in the Island in the Sky District. A second phase was completed in the spring of 2022. Based on this fieldwork we have documented over 100 new fossil localities. We found that the Torrey Member of the Moenkopi contains numerous vertebrate tracksites. Many of these sites preserve Chirotheriid-type swim tracks. Several localities contain small terrestrial tracks tentatively assigned to the ichnogenera *Chelonipus*, *Procolophonichnium*, *Protochirotherium*, *Rotodactylus*, *Synaptichnium*, and others. We directed most of our field efforts to the Chinle Formation because of the high potential for finding significant vertebrate fossils. Northern CANY lies in the Paradox Basin, and Chinle deposition in the region was influenced by salt tectonism. Consequently, Chinle strata in the region are difficult to correlate with Chinle strata elsewhere in southeastern Utah. Workers have recognized the Kane Springs strata that likely correlate to all or parts of the Moss Back, Petrified Forest, and Owl Rock Members. The upper Chinle strata are assigned to the Church Rock Member. One of the goals of our survey was to find taxonomically identifiable vertebrate fossils that can be used for biostratigraphy. Numerous vertebrate localities that include the remains of aetosaurs, metoposaurs, phytosaurs, and fishes from the Chinle Formation were documented and placed in stratigraphic context.

Funding Sources Utah Geological Survey, National Park Service

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

A SMALL AND UNUSUAL K/PG AVIAN TARSOMETATARSUS FROM THE CRETACEOUS-

specimens and integrated them into a molecular phylogenetic backbone containing 69 living species. Within the limits of the available fossil record, we attempted to sample fossil species across major clades and throughout the evolutionary history of Carangaria. Placing fossils within trees for which there are limited morphological datasets is challenging, so we adopted an approach based on a combination of taxonomy and verbally argued placements to assign fossils to specific internodes. The length of the branch subtending fossils (and their branching point along an internode) was inferred analytically. Our strategy uses a maximum likelihood approach to place these fossils under a Brownian motion model of shape evolution, conservatively biasing our results toward supporting a time-homogenous, diffusive model of change. Our integrated results, combining shape data from both extinct and extant species, support elevated rates of diversification early in the history of Carangaria and then slow down thereafter but the clade has continued to accumulate diversity to the present day. These results deviate from the findings using only extant taxa which showed that the Carangarian diversity became constrained soon after rates slowed down. Our findings support the well-established significance of fossil data in understanding patterns of evolutionary diversification and provides one approach toward including fossils in a comparative framework when detailed character matrices are not available.

Funding Sources Funding was provided by NSF DEB 2017822.

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

META-ANALYSIS OF ORIENTATION PATCH COUNT ROTATED (OPCR) AND DIETARY INFERENCE IN TERRESTRIAL AMNIOTES

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The study of dietary ecology in extinct amniotes has been greatly advanced in the last two decades by the development of dental topography metrics. Among these metrics, one of the mostly wide used for dietary inference is orientation patch count rotated (OPCR). Although OPCR has been shown to correlate with diet within various extant terrestrial amniote groups, it is less clear whether these correlations can be extended to fossil amniotes outside these groups. Here, we present a meta-analysis of 16 studies of OPCR and diet in extant terrestrial amniotes for the purpose of determining if there are taxon-neutral associations between OPCR and diet that can be generalized to extinct taxa. Our results indicate that taxon, phylogenetic breadth of the study, and study methods are all important to OPCR results. These results suggest that extreme care should be taken in comparing OPCR values between fossil and extant taxa. To address the challenge of

inferring diet for extinct groups, we present a standardized method of comparing OPCR values from different groups to conservatively estimate if diet differs between the groups, with archaic ungulates serving as an example of how these methods can be applied to infer diet for fossil terrestrial amniotes.

Funding Sources Paleontological Society Student Research Grant

Technical Session 13: Early Archosaurs & Pterosaurs (Friday, November 4, 2022, 1:45 PM)

SUSTAINABLE BIPEDAL LOCOMOTION IN EUPARKERIA? QUANTITATIVE BIOMECHANICAL ASSESSMENT OF ITS LOCOMOTORY CAPABILITIES

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Birds and crocodylians are the only remaining members of Archosauria alive today. They show major differences in posture and gait, which are relative polar opposites in terms of locomotor modes. However, in their evolutionary past, both their broader clades (Ornithodira and Pseudosuchia, respectively) exhibited a multitude of different locomotor modes, including origins of bipedalism. The exact timing and the frequency of the occurrences of bipedalism within archosaurs, and thus the ancestral capabilities of Archosauria, have been widely debated for decades. *Euparkeria capensis* is a central taxon for the investigation of locomotion in archosauriforms due to its phylogenetic position and plesiomorphic skeletal morphology, representing the closest analogue to the ancestor of both major clades. Whilst previous studies have investigated the joint motion capabilities in the hindlimb of this species, no studies to date have yet analysed limb mechanical properties, such as muscular leverage or the capacity to generate joint torques required for motion. Here, we used a musculoskeletal model of the hindlimb of *Euparkeria capensis* incorporating a total of 36 muscles to assess its locomotor capabilities. We systematically changed the body and tail postures in the static simulations to investigate their influence on the maximally sustainable ground reaction force (GRF) and examined the resulting pitch moments around the centre of mass (COM). We sensitivity-tested our analyses through incorporating different methods for estimating the intrinsic muscle parameters for the musculoskeletal model. Whilst all simulations were able to withstand the peak GRFs expected during bipedal locomotion in all postures, the resulting negative pitching moments (pushing the nose down) and their magnitudes around the COM were too large to enable sustainable bipedal locomotion in body and hindlimb poses similar to those of extant bipedally running lizards. It is thus unlikely that *Euparkeria* was habitually bipedal and possibly not even facultatively

bipedal. This is in line with previous morphometric studies, which have inferred that *Euparkeria* was an obligatory quadruped. This bolsters the inference that a tendency for facultative bipedal gait might not have been present in the last common ancestor of Ornithodira and Pseudosuchia, and hence (obligate or facultative) bipedalism arose independently in both without any common prior functional intermediates.

Funding Sources This research was supported by the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme [grant agreement #695517]

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

TAKING SYSTEMATICS BY THE HORNS: TOWARDS A FULLY SAMPLED PHYLOGENY OF CERATOPSIA

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The anatomical evolution and phylogenetic relationships of ceratopsian dinosaurs have been the subject of extensive research in recent years, with new phylogenetic analyses accompanying nearly every one of the several dozen new ceratopsian species descriptions that have been published over the last few decades. However, in many cases, the scope of such analyses has been limited to smaller subsamplings of taxa within Ceratopsia, typically focused separately on either non-ceratopsid ceratopsians or ceratopsids *sensu stricto*, with few combining a broad sampling of both, and fewer still including a sufficient outgroup sampling to polarize many traditionally evaluated ceratopsian characters to the base of Ceratopsia. Here, I present the results of a new set of phylogenetic analyses for Ceratopsia, separately conducted using both parsimony-based and model-based methods of phylogenetic inference. These analyses, which incorporate a complete generic sampling of taxonomically valid ceratopsians as of at least 2018, are based on the evaluation of a new data matrix assembled from a combination of reevaluated and/or revised morphological characters from existing data matrices and a collection of new characters, including a swath of brand new postcranial characters. This matrix, the Ceratopsian Working Group, is on track to be the largest data set of its kind for ceratopsians, and is intended to provide a new strong foundation for future studies of ceratopsian evolution.

Education & Outreach Poster Session

TAR AR: RESEARCHING THE EFFECTIVENESS OF AUGMENTED REALITY ACTIVITIES FOR VISITOR LEARNING AT LA BREA TAR PITS

DeNeve Weeks, Danaan¹, Lindsey, Emily L.¹, Porter, Molly², Sinatra, Gale³, Herrick, Imogen³, Nye, Benjamin⁴, Nelson, David⁴, Swartout, Bill⁴

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Digital technologies have the potential to support informal STEM learning by fostering immersion, interactivity, and engagement with scientific material. AR in particular can overlay digital information on real-world objects and places, revealing and allowing interaction with things the public would normally not see. This is particularly valuable for historical sciences like geology, archaeology, and paleontology, where abstract concepts and unusual/restricted access settings (such as geological or fossil sites, and laboratories) spark curiosity, but also create challenges for fostering learning. However, AR as a tool is still in its nascent stages. Current applications are as likely to be “fun gimmicks” as they are to produce actual learning gains. At La Brea Tar Pits (California, USA) we are researching what makes paleontology learning AR good. We have conducted two AR learning experiences to test whether AR is better at reducing scientific misconceptions relative to traditional static museum signage and test the effectiveness of several modes of AR delivery (VR headset vs handheld, high vs low interactivity). The first experience taught participants about Pleistocene climate, flora, and fauna. We found that handheld high interactivity AR is preferred, and while no AR condition had greater learning outcomes than comparable signage, the AR experience generated greater curiosity. The second experience (currently underway) invites participants to explore how organisms become entrapped in the asphalt seeps in a life-size AR scene. In addition to both of these experiences, we have created versions of each of the extinct Pleistocene animals represented in the AR experiences that can be interacted with Snapchat, Instagram, or native AR on a user's phone, that is immediately suitable for classroom and off-site use.

Funding Sources National Science Foundation AISL grant

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

OCCURRENCES OF *PANTOLAMBDA INTERMEDIUM* IN THE SAN JUAN BASIN, NEW MEXICO, USA

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In the wake of the end-Cretaceous extinction, pantodonts were among the first mammals to achieve truly large body sizes. Paleocene pantodonts occupied large herbivore niches across North America, Asia, and Europe. In North America, the Torrejonian genus, *Pantolambda*, encompasses three species ranging from large dog- to small cow-sized.

Of the three species, *P. intermedium* is the most poorly represented with known material consisting of a fragmentary dentary with m1-2 and isolated lower premolars. All the originally referred material was recovered from the Gidley Quarry, Montana. We describe cranial and postcranial fragments of the species from the Nacimiento Formation of the San Juan Basin (SJB), New Mexico. Interestingly, although it is intermediate in size between *P. bathmodon* and *P. cavirictum*, *P. intermedium* occurs lower in the stratigraphy (Tj2) than these other species and is the first appearance of pantodonts in the SJB.

The presence of *P. intermedium* in the SJB is validated with a worn dentary (NMMNH P-19774) containing m1-2. A pronounced entoconid on m1 and m2 distinguishes these teeth from those of *P. cavirictum*, whose entoconid is weakly developed, and from those of *P. bathmodon*, which lacks an entoconid on the anterolingually-sloping postcrisid. An isolated m3 (NMMNH P-72117) shows a partial, narrow trigonid with a wide talonid basin that is shallower than in *P. bathmodon*. A concreted, partial braincase (NMMNH P-21646) bears low sagittal and nuchal crests similar to *P. bathmodon*. A partial scapula (NMMNH P-21647) preserves the glenoid region and the distal portion of the scapular body. The glenoid cavity is an elongated oval that tapers anteriorly to a prominent, triangular supraglenoid tubercle. A coracoid process distinct from the tubercle is not present. A similar pattern is observed in *P. bathmodon*. The condition observed in *Pantolambda* contrasts with other pantodonts. *Alcidedorbigna* possesses a relatively small tubercle distinct from a rounded coracoid process and the larger-bodied pantodonts, *Barylambda* and *Coryphodon*, exhibit both a prominent tubercle and a well-developed coracoid process.

A prior hypothesis posited that *P. intermedium* from Montana could simply represent larger morphs of *P. bathmodon* following Bergmann's Rule. However, the presence of *P. intermedium* in New Mexico in a similar environment to and at the same latitude as *P. bathmodon* and *P. cavirictum* supports its distinction from the other two morphs as a unique species.

Funding Sources European Research Council Starting Grant (ERC StG 2017, 756226, PalM); National Science Foundation (NSF; EAR 1654952, DEB 1654949)

OSTEOHISTOLOGY OF *TRICERATOPS* FORE- AND HINDLIMB: IMPLICATIONS FOR GROWTH, DEVELOPMENT AND TAXONOMY

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Osteohistological analyses greatly contributed to our understanding of dinosaur growth patterns, metabolism, development, life history and taxonomic position. Many of the major dinosaur groups have been subject to histology-based growth studies, but the derived ceratopsians (ceratopsids) have received little attention. Ceratopsids (chasmosaurines and centrosaurines) belong to one of the most speciose dinosaur groups and are characterized by extraordinary cranial ornamentations. In fact, due to presumed preservation and collection biases, ceratopsids are almost exclusively identified by their ornamented skulls, and many described taxa lack well-preserved post-cranial material suitable for histological sectioning. This prevalent dearth of ceratopsid limb bone material severely hampers any thorough growth studies on this group, and further enhances the uniqueness of the few available specimens in collections.

Here we present a detailed osteohistological investigation on the iconic dinosaur *Triceratops*, based on disarticulated remains from a large monospecific bonebed discovered in the Lance Formation, Wyoming, USA. Multi-element analyses of limb bone material across four different-aged individuals reveal predominantly laminar parallel-fibered bone tissue also containing circumferential rows of longitudinal primary osteons. Bone remodelling is extensive in all elements, but the relative amount of Haversian bone is even more pronounced in the forelimb. Cyclical growth marks are mostly absent, except in skeletally mature individuals, where they form an external fundamental system near the periosteum (max. seven growth lines). The humeri, tibiae and femora also show clear zonation in the form of alternating bone tissue types. These combinations of histological markers indicate a relatively steady and fast growth rate, but not as rapid as observed for other dinosaurs (e.g., hadrosaurs and theropods). Instead, *Triceratops* strongly resembles some of the slower growing sauropods such as *Ampelosaurus* and *Magyarosaurus*. The current limited record of ceratopsian histology hints at marked differences between basal ceratopsians, centrosaurines and chasmosaurines, especially regarding bone tissue and remodelling. This first approach in understanding *Triceratops* bone microstructure – and the presence of a (histologically) skeletally mature *Triceratops* associated with a non-fenestrated frill – will contribute to the debate on the synonymy of *Triceratops* and *Torosaurus*.

Funding Sources The project is funded by the Dutch Research Council (NWO) through ALW Open Programme (ALWOP.633).

Technical Session 2: Paleoecology (Wednesday, November 2, 2022, 8:00 AM)

A COYOTE IN THE “COAL MINE,” OR TAR PIT: ECOLOGICAL CONSEQUENCES OF MEGAFUNAAL EXTIRPATION AND ANTHROPOGENIC IMPACTS

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The end Pleistocene was a time of ecological turmoil, coincident with environmental change, extinctions, and anthropogenic impacts on the landscape. As one of the few persisting predators from the Pleistocene, La Brea's exceptional record of coyotes (*Canis latrans*) provides a unique opportunity to clarify how a recently documented ecosystem state-shift impacted survivors. Through a multiproxy analysis of Rancho La Brea coyotes from the past 50,000 years to present, we analyzed over 100 individuals for radiocarbon chronologies, stable isotopes, dental microwear, and morphology to assess the consequences of megafaunal extirpation on these predators. Most notably, coyotes demonstrate a significant decline in $\delta^{15}\text{N}_{\text{bone collagen}}$ values immediately after the extirpation of megafauna. While this decline is suggestive of a change in diet from more to less meat, stable isotopes of amino acids from a subset of samples instead provide evidence of a baseline shift in nitrogen—indicating large scale changes in the availability of nutritional resources and a broader ecosystem state-shift coincident with increases in fire activity and human populations. While coyotes do not demonstrate notable changes in diet across the extirpation boundary, as inferred from stable carbon isotopes in tooth enamel and dental microwear texture analysis, significant shifts ($p < 0.05$) in stable oxygen isotopes in $\delta^{18}\text{O}_{\text{enamel}}$ and $\delta^{13}\text{C}_{\text{bone collagen}}$ indicate more nuanced changes in potential prey-resources. Coyotes also demonstrate a linear decline in body size that begins prior to the local extirpation of megafauna (~20,000 years ago) and may be in response to competition with larger canids, the decline in large prey, and/or concurrent increases in aridity during this interval. A dramatic increase in scavenging of forested prey (e.g., deer) during the past century stands out as significantly distinct ($p < 0.05$) from the dietary niches occupied over the past 50,000 years—implying dramatic impacts of human behavior on

coyotes, a recent shift in their ecological role, and the highly adaptable nature of these carnivores.

Funding Sources National Science Foundation.

Virtual Posters

SHARK TEETH AND VERTEBRAE FROM THE MARAMBIO GROUP (UPPER CRETACEOUS) OF JAMES ROSS ISLAND, ANTARCTICA PENINSULA

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Chondrichthyan remains are the most frequently found fossil vertebrate in the Marambio Group, distributed among the Santa Marta (SMF), Snow Hill Island (SHIF), and López de Bertodano (LBF) formations. Such fossils are proxies to infer paleodepositional environments. To date, the shark diversity of the Marambio Group comprises Chimaeriformes, Hexanchiformes, Lamniformes, Pristiophoriformes, Squaliformes, Squatiniformes, and Synchodontiformes. Here we present a taxonomic survey of chondrichthyans recovered from Santa Marta Cove on James Ross Island during fieldwork of the PALEOANTAR Project in the austral summer of 2018/19. The specimens comprise vertebrae and teeth. All vertebrae came from the SMF. They are amphicoelic, with concentric bands, preserving the notochord channel, common in the Lamniformes already reported from that unit. We have identified the isolated teeth to the hexanchiform *Chlamydoselachus thomsoni* (Chlamydoselachidae) and *Notidanodon dentatus* (Hexanchidae), both from the SMF, and to the lamniform Odontaspidae from SHIF. The tooth of *C. thomsoni* preserves only the mesial and distal cusps, which are tall and robust, with inflated base. The cusps are vertical and slightly curved. The apex is devoid of enameloid and a collar is seen at the base of the crown of each cusp. The root has a central notch. The tooth of *N. dentatus* preserves only two distal cusps with low crowns. The cusps are sub-equal in shape and strongly bowed in distal direction. It exhibits a mesial cutting surface and has a deep root. The teeth attributed to Odontaspidae came from SHIF and show tall and elongated crowns that are slightly sigmoidal in mesial view. The enameloid is smooth in appearance, devoid of any ornamentation. The roots have a prominent lingual shelf. This set of features resembles *Odontaspis* sp. and *Charcharias* sp., both already reported in the LBF of Seymour Island. This is the first report of Odontaspidae for the SHIF of James Ross Island. Lamniforms were cosmopolitan during the Cretaceous, whereas the hexanchiform *C. thomsoni* is an endemic Antarctic species. *Notidanodon* is found in high-latitude ancient seas of the Weddellian Province. The elasmobranchians reported here corroborate the nearshore marine depositional environment interpretation for the Santa Marta Cove, where the SMF and SHIF crop out. Our results increase the

knowledge about the diversity of the Late Cretaceous chondrichthyans of Antarctica, also elucidating their distribution.

Funding Sources PROANTAR (CNPq #407670/2013-0 and #442677/2018-9), (CAPES # 88887.336584/2019-00) and FAPERJ (#E-26/201.095/2022; #E-26/202.066/2021)

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

ORNITHOPOD CRANIODENTAL REMAINS FROM THE CENOMANIAN GRIMAN CREEK FORMATION, NEW SOUTH WALES, AUSTRALIA

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Neornithischians are some of the most commonly recovered dinosaurs from the mid-Cretaceous of Australia. Despite this, they are incompletely known, largely represented by isolated elements, and taxon diversity estimates rely heavily on the recognition of distinctive tooth-bearing bones. Craniodental remains from the lower Cenomanian Griman Creek Formation (GCF), New South Wales, provide a window into the diversity of Australian ornithopods during the Late Cretaceous. To date, two ornithopods have been named from the GCF: the non-iguanodontian, dentary-based taxon *Weewarrasaurus pobeni* and the non-hadrosaurid iguanodontian *Fostoria dhimbangunmal*, the latter lacking dental remains. In addition to these taxa, two isolated, incomplete, tooth-bearing dentaries from the GCF (AM F105667 and AM F106297) were previously described, although the dentition was inaccessible. These specimens were preliminarily grouped into the single GCF morphotype 'Ornithopod indet. A', defined by a convex ventral dentary margin, a horizontal line of lateral foramina along the rostralateral surface, and a dorsoventrally limited contact surface for the splenial. Here we use synchrotron radiated micro-tomography and digital three-dimensional reconstruction to describe the dentitions of AM F105667 and AM F106297. The preserved dentary crowns of AM F105667 are gracile, when compared to those of AM F106297 and *W. pobeni*. *Weewarrasaurus* differs from AM F105667 and AM F106297 by the presence of markedly elongate lateral foramina on the dentary, teeth with a less-pronounced primary ridge, and curved roots. AM F105667 further differs from *W. pobeni* by the convex ventral margin of the dentary. Given these notable differences, we propose that AM F105667 and AM F106297 represent new taxa. The GCF dentaries were included in two recently published phylogenetic datasets to infer their phylogenetic relationships. However, other than recovery in a basal ornithopod polytomy, the results of the phylogenetic analyses were inconclusive. This study

highlights how the use of CT imaging technology to study internal, inaccessible tooth morphology assists in the systematic investigation of highly incomplete dinosaur fossil remains from Australia. Our results increase the standing ornithopod diversity in the GCF during the early Late Cretaceous, supporting a taxonomic richness comparable to the ornithopod-dominated southern localities in Victoria.

Funding Sources Destination Australian Program (DAP)

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

A UNIQUE MORRISON FORMATION SITE FROM SOUTHERN WYOMING AND ITS FAUNAL IMPLICATIONS

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The McKinsey-REX Quarry, located 8 miles southwest of Laramie, Wyoming, represents a multi-generic Morrison Formation locality located 50 miles from the closest known dinosaur-bearing outcrops of the Formation. The site, found in 2006 during construction of a natural gas pipeline, preserves elements from the skeletons of at least four dinosaurs that represent at least three different genera. The fragmentary skeletal remains of two individual theropods identified as *Allosaurus* are preserved, along with the partially complete skeletons of two sauropods (one diplodocoid, one macronarian). Other material found at the site includes fragmentary turtle scutes and crocodile scutes and teeth. A preserved diplodocoid, with articulated dorsal vertebrae and sacrum, and a partial caudal series, is reliably referred to *Galeamopus sp.* based on the anatomy of the centra and neural spines of the dorsal vertebrae. This represents a rare occurrence of this genus south of northern Wyoming. The macronarian material preserved at the site has previously been suggested to belong to a new species of *Camarasaurus*, but the unusual size of the specimen and a number of minor anatomical features suggest that the specimen may instead be referable to Brachiosauridae. Elements of this specimen include partial cervical and dorsal vertebrae, a scapula and femur, and the majority of the caudal series. This site has been U/Pb radiometrically dated to approximately 152 million years old. The location of this site, in an area relatively devoid of other Morrison sites, and the variety of dinosaurs present provide valuable information regarding the biogeography of sauropod dinosaurs from the Morrison Formation, and the local environment of a section of the Morrison's geographic area that has not previously produced any notable fossil assemblages. Most notably, this site provides insight into the biogeography of *Galeamopus*, and a potential juvenile brachiosaurid, as well as interesting freeze-thaw taphonomy on many preserved elements.

Funding Sources All of the funding for this project was provided by the University of Wyoming.

Technical Session - New Methods (Thursday, November 3, 2022, 10:15 AM)

A NEW BEAMLINE, BM18, AT THE EUROPEAN SYNCHROTRON AND RADIATION FACILITY AND ITS APPLICATIONS FOR PALAEOONTOLOGY

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Synchrotron X-ray imaging has a long and successful history of imaging fossils that would otherwise be difficult to scan using conventional lab CT setups. The introduction of BM18 offers an unprecedented opportunity for the progression of Synchrotron Radiation micro computed tomography (SR μ CT) for palaeontological specimens. BM18 is a high-throughput, large-field, phase-contrast tomography beamline optimized for hierarchical imaging with the highest level of transversal coherence worldwide for a microtomography beamline, and an unprecedented beam size at these energy levels (>100 keV). The building hosts a 45m long white beam experimental hutch, and an optics hutch with three sets of various attenuators for beam attenuation and beam profiling, with a current beam size of 350*18mm². The large sample stage planned for spring 2023 will give access to 250cm vertical field of view for samples up to 300 kg, and will be able to do multiresolution scans from 200 μ m to 0.7 μ m with energy levels of 250 keV at lower resolutions and 120 keV at higher resolutions. These multiresolution capabilities will be made possible through an automated detector stage with up to 9 different detectors, that move along the marble floor of the hutch on air pads, making it possible to cover propagation distances from 0 to 36m. Here, the new beamline is introduced together with an investigation on how the optimization of propagation distance and energy increases imaging quality on fossil specimens. A range of fossil specimens which present different preservation qualities were scanned on BM18 at different propagation distances (2m, 10m and 31m), energy levels (~100keV, ~140keV, ~180keV) and voxel sizes (20 μ m, 6.5 μ m and 2.2 μ m) to compare imaging results. The large sample stage, multi-detector setup, energy ranges and adjustable propagation distance makes this new beamline (BM18) highly suitable for palaeontological experiments and is a ground-breaking step forward for synchrotron imaging of palaeontological specimens.

Funding Sources The ESRF is thanked for inhouse beamtime on BM18. Fraunhofer and BMBF are thanked for their contribution towards BM18.

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

TAPHONOMY OF MOUNTAIN-PROXIMAL VERTEBRATE MICROFOSSIL BONEBEDS FROM THE EARLY PALEOCENE DENVER FORMATION OF THE DENVER BASIN (EL PASO COUNTY, COLORADO)

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Exceptionally preserved vertebrate fossils from the early Paleocene portion of the Denver Formation exposed at Corral Bluffs, east of Colorado Springs, CO—including nearly complete mammal skulls—are shedding new light on the recovery of terrestrial ecosystems in the aftermath of the Cretaceous–Paleogene (K–Pg) mass extinction. Screen-washing of vertebrate microfossil bonebeds (VMBs) is underway to better understand the structure of vertebrate communities at Corral Bluffs, which likely lived closer to the Rocky Mountains than most of the contemporaneous local faunas currently known. Qualitative observations of lower taxonomic richness and abundance of vertebrate microfossils at Corral Bluffs relative to contemporary mountain-distal localities, however, suggest that taphonomic processes that yield VMBs might differ in respect to mountain-range proximity. Here, we present preliminary results comparing the vertebrate microfossils from Corral Bluffs to the Late Cretaceous Judith River Formation of northcentral MT to better understand the taphonomy of mountain-proximal vs. -distal VMBs, respectively. Corral Bluffs VMBs are characterized by high frequencies of small elongate and equidimensional fossils, large plate-like dermal bones including turtle shells, crocodile scutes, and fish scales, and conical crocodile and fish teeth. We quantified the raw size, shape and element distribution, and taxonomic richness of fossils from four Corral Bluffs localities and compared these data to previous studies on the taphonomy of Judith River VMBs. Vertebrate microfossils from Corral Bluffs were (1) statistically significantly larger; (2) more fragmentary and sparse; and (3) taxonomically depauperate relative to those from the Judith River Formation. Although the differences in taxonomic composition and abundance may be explained by the smaller sample sizes (<500 total specimens) and ca. 10-million-year gap separating Corral Bluffs from Judith River VMBs, the differences in size and element preservation may be related to their proximity to paleo-uplands. Vertebrate-microfossil-accumulating sinks in mountain-proximal areas

like Corral Bluffs were possibly less stable, easily disturbed, and therefore captured less of the vertebrate paleo-community than mountain-distal areas. Further sampling and analysis of VMBs at Corral Bluffs will determine whether these preliminary patterns are real or simply artifacts of incomplete sampling.

Technical Session 17: Fish (Saturday, November 5, 2022, 8:00 AM)

FISH ARE NEITHER FRIENDS, NOR FOOD: OSTEICHTHYAN PREDATION OF A SUBADULT PLESIOSAUR

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Embedded teeth are rare in the fossil record, but when found they can remove ambiguity concerning trophic interactions in ancient ecosystems. Here we present an analysis of a tooth attributable to a large osteichthyan fish embedded in the neck vertebra of a polycotyloid plesiosaur. The fossil was collected from the Mooreville Chalk, a Santonian/Campanian marine deposit in Green County, Alabama. The polycotyloid, referred to *Polycotylus latipinnis*, was a subadult at the time of death with an estimated total length of 3.5 m. The vertebral centrum is a mid-cervical. This indicates that the tooth was emplaced during a hard, penetrating bite across the neck at or near the time of death. The tooth is fully embedded in the ventral portion of the centrum in a region of poorly ossified cartilage around the rim. The tooth is broken at both tip and root near the surface of the surrounding bone, and this made its identification difficult. Computed tomographic (CT) scanning was employed to visualize the tooth. The ensuing three-dimensional model revealed a conical, slightly curved tooth lacking obvious serrations, carinae, or other distinguishing features. In addition to the missing tip, the base of the crown near the break was slightly labio-lingually crushed. However, the mid-section of the tooth was well-preserved; the tooth crown lacks the striations found on plesiosaur teeth, and additional sectioning of its interior revealed a large, conical pulp cavity. This pulp cavity is not like the abbreviated cavity seen in mosasaur teeth but is similar to those of fish teeth. Taken together, these characteristics suggested that the tooth belonged to a large osteichthyan fish rather than another marine reptile. Several fish in the Mooreville Chalk are large enough to bear such a tooth, including the crossognathiform *Pachyrhizodus* and the enormous ichthyodectid *Xiphactinus*. The tooth is not a *Xiphactinus* fang, but its size is consistent with other dentition attributable to either taxon. This evidence confirms the complexity of Late Cretaceous, marine trophic

webs, in which the dominant marine reptile groups did not sit unchallenged at the top of the food chain.

Funding Sources This project was funded by the National Science Foundation, IUSE-GEOPATHS-IMPACT 1600376, and the University of Tennessee Division of Student Success.

Education & Outreach Poster Session

TACKLING COMPLEX TOPICS IN THE CLASSROOM USING GAMIFICATION WITH CLIMATE CHANGE: THE BOARD GAME

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The use of games to convey educational concepts has grown in popularity in recent years, and there is a growing body of research that suggests games can be leveraged to increase student engagement with and retention of complex topics. However, successfully implementing educational games in STEM classrooms presents several challenges. Development can be time consuming, as activity design must successfully balance engaging game experiences with curricular requirements. Without training and support, even educators who are positively inclined towards implementing games in their classrooms often return to more traditional teaching methods. As part of an ongoing project to provide high-quality, geoscience-themed lesson kits for Tennessee K-12 educators at little to no cost, collaborators from both paleontological and educational backgrounds generated a lesson kit that converts the complexities of climate change through geologic time into a board game. Players take turns playing cards that feature different forcing mechanisms, including tectonic events, evolutionary innovations, and both naturally occurring and anthropogenic geochemical processes. To move the game piece back and forth on a board that spans runaway icehouse to runaway greenhouse climate conditions. The game was specifically designed to meet Tennessee state science standards' requirements addressing climate change and the carbon cycle; these standards are closely aligned with the *Next Generation Science Standards*, thereby increasing the nationwide applicability of the game. Ongoing testing of the activity is being performed in partnership with local museum educators and a STEM magnet high school in a large metropolitan district. Feedback from these outlets, as well as from participants in a Tennessee Science Teachers Association workshop, has been positive overall. Middle and high school science teachers specifically commented on the both the cognitive and social benefits of interactive board-based gameplay, particularly after the substantial increase in time students have spent on isolated computer-based instruction.

The game touches on both climate change and evolution, two topics that suffer from widespread misunderstanding and ideologically-driven resistance in targeted school districts. Gamification provides a successful mechanism for engaging students with these complicated concepts in a way that makes them accessible without oversimplifying the underlying science.

Funding Sources This project was funded by the National Science Foundation, IUSE-GEOPATHS-IMPACT 1911565.

Virtual Posters

SAUROLOPHINE HADROSAURID (DINOSAURIA: ORNITHISCHIA) SPECIMENS FROM THE CABULLONA GROUP (LATE CRETACEOUS) OF NORTHEASTERN SONORA, MEXICO

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The non-marine deposits of the Campanian–early Maastrichtian Cabullona Group (northeastern Sonora, Mexico) have yielded abundant fossils of continental vertebrates, including dinosaurs. However, this dinosaur fauna has yet to be studied in detail. We describe three partial hadrosauroid specimens from this area. The remains were collected in two localities in the Fronteras Municipality, Puerto Viejo and Arroyo del Alamito. These two sites correspond stratigraphically to the lower part of the 640 m-thick Fronteras section of the Cabullona Group that is dated in its upper part at 76.7 ± 0.7 Ma (using U-Pb, zircon). The Puerto Viejo specimen (2997 P.M. 1) consists of several axial elements, a nearly complete pelvis, and hindlimb fragments. In the Arroyo del Alamito locality, two different sized specimens were collected. The larger individual (2997 P.M. 6) includes an ilium and some axial elements, while the smaller exemplar (2997 P.M. 6 [24/36]) is only represented by a partial right ischium.

A parsimony phylogenetic analysis positioned 2997 P.M. 1 and 2997 P.M. 6 deeply nested within saurolophine hadrosaurids as a member of Edmontosaurini. In particular, the ilia of these two exemplars share with that of the edmontosaurin *Kundurosaurus* a supraacetabular process that projects lateroventrally at least 25% but less than 50% of the depth of the central iliac plate and displays an asymmetrical

caudally skewed lateral profile. Both specimens from Fronteras are united by a proximal region of the preacetabular process of the ilium that is as deep as half the depth of the central iliac plate. Notably, the pubis of the Puerto Viejo specimen shares with that of other Edmontosaurini an oval distal blade that is deeper than long, a prepubic process with pronounced concave profiles of the dorsal and ventral proximal margins, and a prepubic constriction that is longer than the distal blade. The fragmentary preservation of the second exemplar from Arroyo del Alamito, 2997 P.M. 6 (24/36), only allowed placement within Hadrosauridae with unresolved relationships with other members of the clade. The results obtained after analyzing 2997 P.M. 1 and 2997 P.M. 6 provide the first evidence of the presence of edmontosaurin saurolophines as far south in Laramidia as present-day northern Mexico. Otherwise, this tribe of hadrosaurids is known from northern Laramidia and eastern Asia.

Funding Sources AV DGAPA-UNAM fellowship; Grupo México S.A. (C.V.); grants RyC-2015-17388 and PID2020-119811GB-I00 (MCIN/AEI/10.13039/501100011033); CERCA Programme (Gov. Catalonia)

Technical Session 1: Dinosaurs (Wednesday, November 2, 2022, 8:00 AM)

THE INFLUENCE OF SUPRACRANIAL CRESTS ON FEEDING MECHANICS IN HADROSAURIDS (ORNITHISCHIA: ORNITHOPODA)

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Lambeosaurine hadrosaurs exhibited extreme modifications to the facial skeleton, where the premaxillae, nasals, and prefrontals were modified to form their iconic supracranial crests. This morphology contrasts with their sister-group, Saurolophinae, which possessed the plesiomorphic skull condition and arrangement of bones. Although studies have discussed differences between lambeosaurine and saurolophine skull morphology and ontogeny, there is little information detailing suture modifications through ontogeny and evolution. Variation in suture morphology is of particular interest due to its correlation with mechanical loading of the skull in extant vertebrates. Here, we quantify and contrast the morphology of the calvarial (interfrontal and frontoparietal) sutures in iguanodontians to test whether the evolution of lambeosaurine crests impacted mechanical loading of the skull. We predict increased interdigitation in lambeosaurines due to 1) structural support for the crest, and/or 2) differential loading during feeding. We employed the Sinuosity Index (SI) and a windowed short-time Fourier transformation with a Power Spectrum Density estimate (PSD), that elucidate differences in calvarial suture sinuosity and complexity, respectively, in iguanodontians, and in an ontogenetic series of *Corythosaurus* and *Gryposaurus*. ANCOVA was used to statistically evaluate differences between groups. We found

that SI increases through ontogeny in hadrosaurids, although this increase is more extreme in *Corythosaurus* than *Gryposaurus*. Lambeosaurines also have higher SI than other iguanodontians, a difference that is evident in crestless juvenile lambeosaurines, suggesting that increased sinuosity is unrelated to structural support of the crest. No significant differences were found between saurolophines and basal iguanodontians. Similarly, lambeosaurines have higher PSD than saurolophines and basal iguanodontians, while the latter two groups do not differ. We found no ontogenetic differences in PSD. Taken together, these results suggest that lambeosaurine calvarial sutures are more interdigitated than other iguanodontians, and although suture sinuosity increased through ontogeny, overall suture morphology remained constant. These ontogenetic and evolutionary patterns suggest that increased suture complexity in lambeosaurines coincides with crest evolution, and corresponding modifications to their facial skeleton significantly altered the distribution of stress while feeding.

Funding Sources This research is funded by a NSERC Vanier Canada Graduate Scholarship to TWD and a NSERC Discovery Grant to DCE (RGPIN-2018-06788).

Technical Session 3: Marine Reptiles (Wednesday, November 2, 2022, 8:00 AM)

COPROLITE EVIDENCE FOR MARINE VERTEBRATE MIGRATION IN THE WARM CRETACEOUS ARCTIC

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Although the migration of large vertebrates across terrestrial and marine systems greatly impacts the ecosystems they cross and connect, fossil evidence for migration is elusive. However, we have found surprising evidence that supports the occurrence of ancient migration in the form of a mismatch between the abundance of skeletal fossils and coprolites. An Upper Cretaceous fossil assemblage from the Kanguk Formation on Devon Island in Nunavut, Canada, shows thousands of sand-rich coprolites and only a modest number (~100) of vertebrate body fossils, suggesting a substantial number of visiting vertebrates. This assemblage is also unique in that it represents an Arctic community that lived in warm temperate conditions with seasonal extremes in photoperiod, an environment that has no modern analog. Our objectives were to evaluate the likely vertebrate defecators at this site, investigate evidence that these organisms were migratory, and consider the impact of seasonal migratory visitors in the warm Cretaceous Arctic. Previous studies at this locality have already documented highly abundant diatoms, suggesting robust seasonal blooms. Fossils of invertebrate prey such as squid and decapod crustaceans often occur within coprolites.

Skeletal fossils of vertebrates include sharks, plesiosaurs, and bony fish such as *Xiphactinus* and *Enchodus*. Carnivorous marine vertebrates were assessed on their ability to ingest large amounts of sediment during feeding, and prey in the coprolites were analyzed with computed tomography for evidence of digestive processing. These analyses indicate that the two most likely defecators were sturgeons and elasmosaurid plesiosaurs. Four lines of evidence support the occurrence of migration at this site: 1) the large differential between the number of body fossils and coprolites; 2) the likely defecators had the physical capabilities and plausible motivations to migrate; 3) the abundant microfossils likely reflect seasonal blooms of planktonic organisms responding to increased seasonal daylight just as plankton in the Arctic do today; and 4) modern Arctic systems host many migratory organisms. Both likely defecators could have been migratory visitors exploiting seasonal food resources from the benthos. This Cretaceous Arctic assemblage offers rare fossil evidence that supports the occurrence of seasonal marine migration in a temperate Arctic that likely impacted resource cycling along a latitudinal gradient in the Western Interior Seaway.

Funding Sources University of Colorado Boulder Department of Geological Sciences (Outstanding Geology Major Kolber Scholarship and Outstanding Student award)

Technical Session 17: Fish (Saturday, November 5, 2022, 8:00 AM)

ACIPENSERIFORM FISH FOSSILS REVEAL KPG IMPACT SEASON

During, Melanie A.¹, Voeten, Dennis F.¹, Sanchez, Sophie¹, Ahlberg, Per E.¹, Smit, Jan², Verdegaal-Warmerdam, Suzanne², Van der Lubbe, Jeroen H.², Berruyer, Camille³, Tafforeau, Paul³, Stein, Koen H.⁴

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The Cretaceous–Paleogene (KPG) mass extinction was triggered by the Chicxulub asteroid impact and eliminated approximately 76% of species. The recently discovered Tanis seiche deposit in North Dakota represents an extraordinary record of the direct effects of the Chicxulub impact. Osteohistology and stable isotope archives of exceptionally well-preserved perichondral and dermal bones in acipenseriform fishes from the Tanis deposit were used to reveal annual cyclicity across the final years of the Maastrichtian and demonstrate that the catastrophic impact occurred in boreal spring. Annual life cycles drive the seasonal timing and duration of reproduction, feeding, and hibernation, and in many taxa, reproduction and growth take place during spring. We therefore postulate that the seasonal timing of the Chicxulub impact in boreal spring and austral autumn importantly contributed to selective biotic survival

across the KPg boundary.

Additionally, we used synchrotron microtomography to visualize and describe the osteology of a partial paddlefish from this assemblage. Comparison with the two extant paddlefishes, *Polyodon* and *Psephurus*, and with fossil forms, including the Maastrichtian *Paleopsephurus*, shows that the Tanis paddlefish represents a new taxon. The specimen likely perished by suffocation with impact spherules and/or subsequent entombment in sediment mobilised by the seiche wave. Spherules are almost exclusively encountered between the second and the third gill arch, possibly indicating the main respiratory water flow path. Because the gill arches are obscured by a gill cover that cannot be removed without damaging the specimen, such details would remain invisible without the use of synchrotron microtomography.

Funding Sources Wenner-Gren Foundation, Vetenskapsrådet, European Association of Vertebrate Palaeontologists (EAVP) Annual Research Grant, European Synchrotron Radiation Facility (ESRF), BM05.

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

SYNCHROTRON μ CT IMAGING REVEALS "GRAVITHOLUS ALBERTAE" AS A MATURE END-STAGE STEGOCERAS VALIDUM

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The taxonomic validity of *Gravitholus albertae* (TMP 1972.027.0001), a dome-headed pachycephalosaurid from the Campanian Belly River Group (Alberta, Canada), remains unresolved forty years after its first description. TMP 1972.027.0001 has been variously referred to *Stegoceras* sp., like *Hanssuesia sternbergi*, and as an indeterminate pachycephalosaurid. The diagnosis for *G. albertae* is tenuous and extensive cranial fusion in the holotype, and sole specimen (TMP 1972.027.0001) has hindered a thorough description and taxonomic referral. Synchrotron μ CT imaging was used to identify fused sutures and segment the individual elements that comprise TMP 1972.027.0001 and assess its ontogenetic status (via vascular density). Using new observations of peripheral contacts, frontoparietal morphological distinction of TMP 1972.027.0001 from other Belly River pachycephalosaurids was tested with bivariate and Principal Component Analyses.

TMP 1972.027.0001 is comprised of a fused frontoparietal, a partial nasal, prefrontal, and palpebral, and both posterior supraorbitals and postorbitals. The pear-shaped dome extends to the posterior and lateral margins of the skull, and along with its sparse vascularity, are expected for an end-stage semaphoront of *Stegoceras validum*. The diagnostic small

endocranium of "*G. albertae*" is not supported by bivariate analyses. A Principle Component Analysis based on 15 homologous linear frontoparietal measurements found no size independent separation between TMP 1972.027.0001, *H. sternbergi*, and *Stegoceras validum*, although this cluster was separated from other Belly River taxa. The purported diagnostic wide frontoparietal and inflated supraorbital lobes of *H. sternbergi* is not supported in PCA or bivariate analyses but are consistent with allometric patterns of *S. validum*. We propose that *H. sternbergi* and "*G. albertae*" are synonymous with *S. validum*. Large *S. validum* frontoparietals show statistically significant dimorphism in the thickness of the frontonasal boss. This is not apparent in juvenile and subadult specimens. Taller-bossed morphs include specimens previously assigned to all three taxa. "Shorter" bossed morphs only include specimens previously assigned to *H. sternbergi*. Pathologies consistent with intraspecific combat ("headbutting") appear restricted to frontoparietal domes with proportionally taller frontonasal bosses, and suggests that the two morphs represent sexual dimorphs, rather than separate species.

Virtual Posters

FILLING BRAIN SIZE ESTIMATE GAPS IN EXTINCT BIRDS

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Many comparative neurology studies of extant birds have established relationships between relative brain region size and the relative importance of the function that region serves. These relationships are used to make functional inferences about extinct birds, whose behaviors can never be directly observed, based on their brain endocasts. Relative size of a brain region is calculated from the absolute size of the brain region and the absolute size of the brain, but complete, 3D-preserved skulls of birds are rare in the avian fossil record. Fragments of 3D-preserved skulls including impressions of some brain regions occur in the fossil record and are important data points in the sparse fossil dataset representing avian brain evolution in deep time. But without a total brain size for comparison, the relative size of the brain region in these fossils cannot be calculated and thus functional inferences cannot be made. To address this problem, I assessed foramen magnum size and body mass as predictors of brain volume. The foramen magnum is the opening at the back of the skull that the brainstem passes through to become the spinal cord. It is formed by dense bone, so it may have a good chance of being preserved in the fossil record, and its proximity to the brain could make it a good proxy for brain size. Body mass can be calculated in extinct birds from a number of measures of easily-preserved limb bones, and the relationship between brain volume and body mass is well known in comparative neurology. I regressed the brain volumes of 114 extant species of birds on foramen magnum width, height, and area and on

body mass. I found a positive, significant, and strong relationship between brain volume and all three foramen magnum metrics, with each regression yielding adjusted R^2 values between 0.8 and 0.9. The strongest relationship was between brain volume and body mass, with an adjusted R^2 value of 0.93. As both metrics are good predictors of brain size, which one is more appropriate will depend on which of the bony elements are preserved in the fossil and the desired application of predicted brain size. These results indicate that foramen magnum size or body mass can be used to calculate a likely brain volume for extinct birds in which those characters are preserved but the endocranial cavity is not, thus allowing us to incorporate more fossil data points into our reconstructions of avian brain evolution.

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

RHYNCHOSAURS (STENAULORHYNCHINAE) FROM THE RED MARL FORMATION, LUANGWA BASIN (ZAMBIA) REINFORCE CORRELATION WITH THE RUHUHU BASIN (TANZANIA) AND MIDDLE-LATE TRIASSIC ASSEMBLAGES OF SOUTH AMERICA

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Rhynchosauria is a clade of archosauromorphs that lived exclusively in the Triassic: they evolved in the immediate recovery from the end-Permian mass extinction and became globally distributed herbivores throughout the Middle Triassic. Due to their local abundances, and the limited stratigraphic range of individual taxa, rhynchosaurs can be used for biostratigraphic correlation. Biostratigraphy links successive Triassic assemblages across southern Pangea, and recently it has become clear that assemblages in Zambia, Tanzania, and Namibia that have been formally considered Anisian are more likely Ladinian or even Carnian (Late Triassic) in age. Here we describe the anatomy of several isolated skull elements from multiple individuals from the Triassic Red Marl of the central Luangwa Basin, Zambia: a partial maxilla with teeth, two toothed partial dentaries (including anterior tip, demonstrating the splenial symphysis), and a pair of associated prearticulars (with medial adductor fossae). The material, although fragmentary, possesses numerous rhynchosaur synapomorphies, including the typical blade and groove jaw apparatus of the mandible (Rhynchosauria) and the lack of dentary contribution to the symphysis (Rhynchosauridae). The partial maxilla possesses a large, lingual field of teeth similar to that in *Ammorhynchus navajoi*, and a synapomorphy of the rhynchosaurid clade Stenaulorhynchinae. Hyperodapedontine rhynchosaurids possess scattered lingual teeth, rather than fields. Before the discovery of these specimens, Triassic assemblages in the Luangwa Basin were largely considered to be confined to the

Ntawere Formation. The confirmed presence of rhynchosaurs within the Red Marl or "upper Ntawere" improves comparisons between the mid-upper Lifua Member of the Manda beds in Tanzania, where the stenaulorhynchine *Stenaulorhynchus stockleyi* makes up ~20% of the assemblage. Additionally, Zambian stenaulorhynchines reinforce biostratigraphic links with Ladinian-Carnian assemblages in Argentina (Tarjadia Assemblage Zone (AZ) of the Chañares Formation) and Brazil (*Dinodontosaurus* AZ of the Santa Maria Supersequence).

Funding Sources National Geographic Society: 158R-18 to BRP

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

AN EARLY PALEOCENE (DANIAN) RECORD OF MOONFISHES (CARANGARIA: MENIDAE), WITH IMPLICATIONS FOR EARLY DIVERSIFICATION IN CARANGARIAN FISHES

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Carangaria (jacks, flatfishes, billfishes, and kin) are a morphologically diverse clade of primarily marine spiny-rayed fishes characterized by a wide array of peculiar behavioral and anatomical novelties. The oldest undisputable body-fossil records of carangarians are from around the Paleocene-Eocene boundary, with many examples from faunas apparently coincident with the Paleocene-Eocene Thermal Maximum (~56 Ma). Molecular clocks point to the origins of the group late in the Cretaceous or early in the Cenozoic. Here, we report on a new species of the carangarian *Mene* from the Eastern Desert of Egypt. The fish-bearing horizon characterizes the anomalous marl beds of the Latest Danian

Event, a hyperthermal, and is securely dated to 62.2 Ma. Assignment of the new specimens to *Mene* is supported by numerous synapomorphies (e.g., compressed disc-like body, anteroposteriorly elongated dorsal and anal fins with relatively short rays, narrow pelvic fins with a compressed and greatly elongated second ray. However, these new specimens exhibit a unique combination of features compared to other species of *Mene*: separate first and second neural spines, no lateral laminar expansions of the dorsal pterygiophores, rounded dorsal and ventral profiles of the maxilla, a distinctive patterns of ridges on the frontal-supraoccipital crest, straight posterior border of the angular, and a rectangular shaped ceratohyal with no dorsal expansion. These suggest that the Danian *Mene* from Egypt represents a new species, with the retention of primitive features indicating it might represent the sister lineage of all other members of the genus. The discovery of definitive material of *Mene* in the early Paleocene extends the record of that genus by over six million years. More significantly, the highly specialized anatomy of *Mene* makes the new Egyptian fossils an robust new marker for establishing the timeline of diversification within Carangaria, and indicates that some of the most specialized anatomies within the group were already present a few million years after the Cretaceous-Paleogene extinction. The remarkable similarity of *Mene* species over 60 million years of evolutionary history represents a striking example of anatomical stasis.

Funding Sources Mansoura University, American University in Cairo, University of Michigan

Romer Prize Session (Thursday, November 3, 2022, 8:00 AM)

CROCODYLIFORM BODY SIZE TRACKS PRECIPITATION AND LIZARD BODY SIZE TRACKS LOCAL TEMPERATURE OVER DEEP TIME INTERVALS

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Extant reptiles are particularly susceptible to changes in temperature and precipitation. But the effects of shifts in these climate variables on reptiles over geologic time spans are poorly understood. Metabolic theory for ectothermic vertebrates predicts that maximum body size should correlate with environmental temperature over ecological time scales. Here, I test this theory on an evolutionary time scale using both paleotemperature and paleoprecipitation for two higher order reptile groups occupying different habitats. I hypothesize that maximum snout-vent length (SVL) in both terrestrial lizards and semiaquatic crocodyliforms tracks temperature and precipitation over deep time intervals, and that these patterns emerge across both regional and local geographic scales.

I measured 283 lizard and 280 crocodyliform fossil specimens from intermontane basins across the Western Interior of North

America through the Paleogene (66-23 Mya), which spans warming, cooling and aridification events. I used extant regressions to reconstruct body size from isolated cranial or limb bones for both groups. I also collected over 100 estimates each for mean annual paleotemperature (MAPT) and paleoprecipitation (MAPP) from literature and tested for correlation between these variables and maximum SVL in lizards and crocodyliforms.

My results indicate that during the warmest interval in the early Eocene, maximum lizard SVL (about 1 meter) had a positive relationship with local terrestrial paleotemperature within basin assemblages over geologic time scales but did not correlate strongly with paleotemperatures averaged across the Western Interior. In contrast to the lizards, maximum crocodyliform SVL (about 2 meters) was consistently high across the intermontane basins through the Paleogene and indicated a strong linear relationship to paleoprecipitation rather than temperature. Large-bodied crocodyliforms were most abundant in localities that hosted large bodies of water at the time of deposition. Maximum body size and diversity decreased for both lizards and crocodyliforms in the early Oligocene, when the Western Interior experienced cooling and aridification. Neontological studies of lizard and crocodylian ecology and physiology corroborate these paleontological observations. These results offer new evidence that climate variables affect body size in ectothermic reptiles on evolutionary time scales, which deepens our understanding of these dynamics on ecological time scales.

Funding Sources SVP, Dept. of Integrative Biology at UC Berkeley, UCMP, Geological Society of America, Evolving Earth Foundation, Burke Museum of Natural History and Culture, Sigma Xi.

Romer Prize Session (Thursday, November 3, 2022, 8:00 AM)

INTRODUCING THE EARLY HIGH DISPARITY PHYLOGENETIC COMPARATIVE MODEL, WITH APPLICATIONS TO BODY SIZE EVOLUTION IN WHALES (MAMMALIA:CETACEA) AND ICHTHYOSAURS (REPTILIA:ICHTHYOSAURIFORMES)

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Phenotypic evolutionary models currently employed in phylogenetic comparative methods (PCMs) estimate parameters describing evolutionary rates and modes of morphological disparity. These models include Brownian Motion (BM), Trend (TR), Ornstein-Uhlenbeck (OU), and Early Burst (EB). In their standard forms, all of these models assume morphological disparity either increases or remains constant throughout the history of a clade. The fossil record deviates from this expectation, revealing many clades have experienced disparity peaks before their eventual extinctions

(or before the present). Currently, no PCMs exist which incorporate parameters for describing Early High Disparity (EHD) in the history of a particular clade. A novel PCM for modelling the evolution of disparity through time is presented here, targeting clades which may display EHD. This model is a combination of EB and OU models, resulting in exponential increases in disparity, followed by rapid disparity decreases around an optimal value, remaining constant afterwards. The EHD model is tested with a dataset of whales and ichthyosaurs, using body size as the trait of interest and time-calibrated phylogenies. Both clades of secondarily aquatic tetrapods passed through and adapted to shallow seas, complex environments subject to greater temperature, sea level, nutrient, etc. variabilities, producing greater niche variability, and thus greater disparity, before adapting to open-ocean environments with more hydrodynamic constraints (and thus lower disparity). This ecological transition potentially resulted in patterns of EHD in cetaceans and ichthyosaurs. The relative model fit (ΔAIC_c) of the EHD models in the cetacean and ichthyosaur datasets are compared to model fits of BM, OU, EB, and TR models, using *fitContinuous_paleo* in R. For cetaceans, BM and OU models are rejected ($\Delta AIC_c > 2$), while TR, EB, and EHD models receive equivalent levels of support ($\Delta AIC_c < 2$). For ichthyosaurs, EB and EHD models receive equivalent levels of support ($\Delta AIC_c < 2$), but strongly reject all other models tested ($\Delta AIC_c > 10$). The EHD model needs testing on other comparative datasets to assess the fit of this model across a taxonomic range. Paleontological datasets contain information on changes in disparity that cannot be inferred easily from extant-only datasets. The novel EHD PCM is the first model which takes into account a mode of evolution in disparity which can only be inferred with extinct taxonomic data.

Romer Prize Session (Thursday, November 3, 2022, 8:00 AM)

A DEVONIAN FISH TALE: A NEW METHOD OF BODY LENGTH ESTIMATION IN PLACODERMS SUGGESTS MUCH SMALLER SIZES FOR THE FAMENNIAN ARTHRODIRE *DUNKLEOSTEUS TERRELLI*

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Late Devonian arthrodire placoderms have long captured popular and scientific interest due to their large size, armored bodies, and status as some of the geologically oldest vertebrate apex predators. However, the exact sizes of these fishes have been controversial as only their head and bony thoracic armor are preserved in the fossil record. Previous length estimates for one of the largest Late Devonian arthrodires, *Dunkleosteus terrelli*, have ranged from 5-10 m but are largely either speculative “guesstimates” or based on comparison with much smaller relatives. Recent size estimates, based on upper jaw perimeter in sharks, have produced lengths of 6-8 m. These length estimates require

unrealistic body proportions for arthrodires such as shortened, shrunken heads and hyper-elongate bodies (at odds with whole-body arthrodire fossils) and said method fails to accurately estimate length in arthrodires for which the entire body is known. Arthrodires have wider mouths than sharks at similar body sizes, making length estimates based on mouth dimensions unreliable. “Orbit-opercular length” (OOL) is proposed here as a useful alternative, which encompasses the allometrically constrained neurocranium and gill regions but excludes the ecologically variable rostrum. This method is highly accurate ($r^2 = 0.93$, percent error = 19.2%) on a sample of 457 species of extant fishes. It also accurately estimates total length within $\pm 10\%$ in arthrodires for which complete remains are known, like the middle Devonian *Coccoosteus cuspidatus*. Applying this model to *D. terrelli* produces lengths of only 3.5 m for CMNH 5768 (substantially smaller than previous estimates), the famous specimen that serves as the basis for most casts of *Dunkleosteus* seen throughout the world. The largest known specimen of *Dunkleosteus terrelli* (CMNH 5936) is estimated as approximately 4.0 m in length (and no more than 5 m), smaller than the largest extant predatory sharks (e.g., *Carcharodon carcharias*). These estimates result in a short, deep body in *D. terrelli*, even compared to other arthrodires, suggesting this taxon converged with other deep bodied, pelagic vertebrates (lamnids, tunas, ichthyosaurs) in body shape. Late Devonian arthrodires were much smaller than previously thought and vertebrates may not have reached sizes comparable to modern marine megafauna until the Carboniferous, suggesting our understanding of vertebrate body size expansion during the middle Paleozoic needs to be revised.

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

DIVERSITY PATTERNS OF FRESHWATER TELEOST FISH IN THE CENOZOIC OF AFRICA

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Past diversity patterns can illuminate environmental shifts, and fluctuating food resources, yet have rarely been investigated in the Cenozoic fossil fish record of Africa, especially in the context of hominin evolution. While aquatic resources are posited to have been a food source for hominins, the stability of this resource in the context of late Cenozoic environmental change is poorly known. Here, we investigated the teleost fish fossil record broadly in Africa during the Cenozoic using the Paleobiology Database. We then analyzed the well-sampled Koobi Fora Formation (KFF) from Kenya, providing a preliminary analysis of changes in taxonomic turnover of fish during the Quaternary, a critical period concurrent with the emergence of the genus *Homo*. We found that the number of occurrences in the Neogene and Quaternary was much higher than the Paleogene, with a majority of fossils collected from

eastern Africa. The raw number of families sampled was roughly consistent from the late Miocene to the Holocene. The Cenozoic data was divided into seven-time bins and turnover was measured using pairwise dissimilarity indices. The modified Forbes index, which corrects for uneven sampling, showed that Paleogene time bins were more dissimilar (~30-50%) compared to the Neogene-modern time bins. Interestingly, catfishes (order Siluriformes) and cichlids (family Cichlidae) were ubiquitous throughout the Cenozoic. A dataset of teleosts from KFF (last 2 million years) was divided into four-time bins, three in the Pleistocene and one in the Holocene, corresponding to dated volcanic tuffs. Overall, low turnover (<5.0%) characterizes the Quaternary assemblages, with the greatest difference in occurring between the Pleistocene and the Holocene, indicating that the diversity of teleost fish remains stable during the last 2 million years. The slight increase in turnover could be explained by sampling bias due to intense research focus on Pleistocene assemblages in eastern Africa associated with early hominins. Large-bodied fish (e.g., catfish) were consistently present throughout the formation and, given their utility as food sources for modern human populations in the region, may have provided a stable source of food despite lake-level fluctuations during glacial-interglacial cycles. More fine-scaled sampling of paleoenvironments in eastern Africa has the potential to elucidate why diversity patterns of aquatic fauna might differ from those seen in the terrestrial fauna.

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

ELEMENTAL CONSTITUENTS WITHIN FOSSILISED DINOSAUR SKIN AND THEIR POTENTIAL TO BOOST RATES OF SKIN PRESERVATION

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The preservation of dinosaur skin in the fossil record is an infrequent event. Although widely referred to as “impressions”, many skin specimens exhibit distinct mineralisation, colour, and/or texture compared to the surrounding sedimentary matrix, suggesting a more complex preservational history. Rapid burial and sediment anoxia typically aid the preservation of soft tissues, but we are yet to understand the chemical constraints and mechanisms that preserve skin—and whether these vary between taxa, depositional settings, and geological ages. Moreover, the significantly higher rate of skin preservation among hadrosaurids compared to other contemporaneous dinosaurs furthers the hypothesis that differential skin properties in-life also drive increased preservation potential, and which may be reflected by their preserved chemical composition.

Here, we apply energy-dispersive X-ray spectroscopy to observe the elemental composition of an initial set of specimens from two distinct depositional settings: indeterminate hadrosaurid skin from the fluviodeltaic Dinosaur Park Formation (Upper Cretaceous) and skin of the nodosaurid *Borealopelta* from the marine Clearwater Formation (Lower Cretaceous). Samples of skin were cut and polished flat, exposing a fresh cross-section before a conductive coating of gold or carbon was applied for viewing under a scanning electron microscope. We found that the Dinosaur Park hadrosaurid skin specimens are relatively depleted in carbon but strongly enriched with iron, which contrasts with the silicon, aluminium and calcium-rich but iron-poor composition of the matrix and supports prior work that suggests secondary iron replacement aids skin preservation. However, *Borealopelta* skin is carbon-enriched and no more concentrated in iron than the surrounding matrix. These initial results reflect the highly variable modes of skin preservation that exist and support the need for further sampling at a broader taxonomic and taphonomic range to better constrain the role of chemical replacement in preserving skin across space, time, depositional environment, and phylogeny.

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Technical Session 20: Crocodylomorpha (Saturday, November 5, 2022, 1:45 PM)

ENCEPHALIC BLOOD FLOW EVOLUTION IN THALATTOSUCHIAN CROCODYLOMORPHS

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Thalattosuchians were a clade of predominately marine crocodylomorphs known from the Jurassic and Cretaceous Periods. Within Thalattosuchia one subclade, Metriorhynchidae, evolved into pelagic forms with flippers and a tail fin. Interestingly, all thalattosuchians had hypertrophied cephalic venous systems not just the pelagic metriorhynchids. We hypothesize that thalattosuchians had increased encephalic blood flow compared to extant crocodylians, and that the endocranial shifts that necessitated this increased blood flow occurred prior to the major evolutionary transition that gave rise to the pelagic

metriorhynchids. To test these hypotheses, we built a CT dataset consisting of 23 extant crocodylians, 13 thalattosuchians, and four non-thalattosuchian fossil crocodylomorphs. From the CT datasets, we digitally segmented the brain endocasts (subdividing them into the olfactory bulbs, pituitary fossa, fore-, mid, and hindbrain), and calculated flow rates based on the radii of the carotid and orbital artery canals. We found that thalattosuchians did indeed have higher encephalic blood flow rates than extant crocodylians. Thalattosuchians had marginally larger pituitary fossae relative to whole endocranial volume than other crocodylomorphs, but overall, endocranial proportions were consistent between groups. Encephalic blood flow increased almost isometrically relative to endocranial volume in both extant taxa and thalattosuchians, however the flow rate is higher in the latter. Relative endocranial volume is lower than that of extant taxa in non-metriorhynchid thalattosuchians, but greater in metriorhynchids. This supports the hypothesis that increased encephalic blood flow is ancestral to all thalattosuchians and suggests that blood flow through the carotid foramen did not increase to meet the energetic demands of a larger brain. Instead, we hypothesize that the soft tissues of the snout, such as salt glands or a thermoregulatory structure, were the drivers of the hypertrophy of the carotid canal in the ancestral thalattosuchian. This may have facilitated the encephalization of metriorhynchids if the flow of blood decreased in the orbital or ethmoid arteries, and increased in the various cerebral arteries, all of which are supplied by the carotid artery.

Virtual Posters

A 3D GEOMETRIC MORPHOMETRIC ANALYSIS OF THE SACRUM IN PINNIPEDS

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The form and function of the sacrum is of great relevance to understand the evolution of locomotion in tetrapods because it is a key piece of the vertebrate skeleton. The sacrum connects the caudal with the presacral region of the vertebral column and the hindlimbs through the pelvis. Here, we extend a previous study on this element for terrestrial mammalian carnivores to aquatic ones (i.e. pinnipeds, families Otariidae, Phocidae and Odobenidae). We use 3D geometric morphometric methods to explore the morphological variability and disparity of the sacrum of a set of terrestrial and aquatic carnivorous species. Our results show that the morphology of the sacrum of each pinniped family is remarkably different, and these differences may be related to the mode of locomotion (pectoral or pelvic oscillation) such as the use of hind limbs to support body weight (terrestrial carnivores and otariids in contrast with phocids) and the presence or absence of a functional tail. In addition, disparity

through time analyses indicate that the sacrum of pinnipeds is less constrained than that of terrestrial carnivores, which points to a gravitational origin of such constraints. In conclusion, our results further confirm the important role played by this skeletal structure in the locomotory adaptations of mammals and promise more interesting results in the future.

Funding Sources This study has been funded by Junta de Andalucía (grant no. P18-FR-3193).

Technical Session 9: Mammals (Friday, November 4, 2022, 8:00 AM)

NEW TAXA FROM THE LATE OLIGOCENE AND EARLY MIOCENE OF THE PACIFIC NORTHWEST ELUCIDATE TRENDS IN BASAL PAN-PINNIPED DENTAL EVOLUTION

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Basal pan-pinnipeds detail the sequence in which aquatic adaptations were acquired in the lead-up to the origin of crown clade Pinnipedia. Here we present a new pan-pinniped known from a skull, vertebra, and humerus, from the late Oligocene Pysht Formation of Washington, USA. This taxon is diagnosed by its posteriorly broad palate, anteriorly narrow rostrum, deep zygomatic arches, and posterior accessory cusps on P3-4. It represents the northern-most occurrence of *Pinnarctidion*, a genus previously restricted to California and Oregon. A morphologically distinct but unnamed taxon represented by a skull and mandible (LACM 128004) from the same locality as *Pinnarctidion* n. sp., the smallest bodied stem pinniped known to date, exhibits primitive dental characteristics similar to those of *Enaliarctos*. A second new, unnamed pan-pinniped from the early Miocene Astoria Formation of Oregon (LACM 127974) shares derived features matching those in *Pinnarctidion*. Comprehensive phylogenetic analysis of early-diverging pan-pinnipeds reveals that several widely accepted genera are paraphyletic and illuminates the multi-step transition of a carnassial-based dentition to homodonty.

Technical Session 5: Amphibians & Early Reptiles (Thursday, November 3, 2022, 8:00 AM)

ANATOMY AND PHYLOGENETIC POSITION OF THE BIZARRE, LARGE-HEADED REPTILE *SPHODROSAURUS PENNSYLVANICUS* (UPPER TRIASSIC; PENNSYLVANIA, USA)

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Most Triassic terrestrial diapsid reptiles belong to two major clades, Lepidosauromorpha and Archosauromorpha. Nevertheless, the phylogenetic relationships of some Triassic taxa have remained uncertain for decades because of limited anatomical knowledge or unusual combinations of features. One such enigmatic taxon is the small-sized *Sphodrosaurus pennsylvanicus* from the Upper Triassic (Norian) of Pennsylvania (USA). Initially identified as a procolophonid parareptile, it was most recently interpreted as a neodiapsid of uncertain affinities. We have restudied the holotype and only known specimen of *Sphodrosaurus pennsylvanicus* and coded it in a quantitative phylogenetic analysis for the first time. This analysis is focused on Permo-Triassic neodiapsids and based on data matrix composed of 190 terminals and 887 characters. *Sphodrosaurus pennsylvanicus* is recovered in this analysis as a doswelliid proterochampsian within Archosauromorpha. The position of *Sphodrosaurus pennsylvanicus* within the clade Doswelliidae + Proterochampsidae is supported by cervical vertebrae with a median longitudinal keel that extends ventral to the centrum rims and pedal unguals of digits II–IV longer than all non-ungual phalanges of the same digit, whereas this species shares with other doswelliids the absence of an external mandibular fenestra, the presence of posterior cervical and anterior dorsal ribs with short tubercula, and a plate-like pubis without an anterior apron. The newly discovered phylogenetic position of *Sphodrosaurus pennsylvanicus* as a doswelliid removes it as a potentially endemic component of the Triassic tetrapod assemblages of North America. A distinctive feature of this taxon is its proportionally very large skull. Phylogenetic Generalized Least Squares regressions confirmed that *Sphodrosaurus pennsylvanicus* has a larger skull than most early diapsids. Optimization on the phylogeny of the skull width versus presacral length ratio shows that the most likely scenario is that the extremely broad skull of *Sphodrosaurus pennsylvanicus* is autapomorphic, but it is not unique among archosauromorphs, being present in hyperodapedontine rhynchosaurs and the proterochampsian *Proterochampsia barrionuevoi*. Exploration of a morphospace of linear measurements shows that *Sphodrosaurus pennsylvanicus* shares close similarities with the probably semi-aquatic *Proterochampsia barrionuevoi*, suggesting that the former had a similar mode of life.

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Technical Session 15: Theropods (Saturday, November 5, 2022, 8:00 AM)

A NEW TROODONTID AND POSTCRANIAL EVOLUTION AMONG PARAVIANS

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We describe a new troodontid from the Late Cretaceous deposits of Bor Gurve, in Dornogov Aimag, Mongolia. The holotype and only known fossil of the new taxon consists of an articulated skeleton preserving the entire postcranium. Apomorphic distinguishing traits include the lack of ossified tendons in the caudal vertebrae and pronounced anterior spikes of the obturator process, a feature also observed in “micro-troodontids” from the Djadokhta Formation at Ukhaa Tolgod, Mongolia. CT scanning of the perfectly articulated hand reveals the presence of a pisiform, which is considered to be absent among non-avian coelurosaurs. Unlike the majority of Cretaceous Mongolian dinosaur fossils, the holotype preserves keratinous sheaths covering the unguals, revealing for the first time the three-dimensional form of troodontid claws. Osteohistological analyses performed on the diaphysis of the radius indicate the individual is near somatic maturity. Femur length exceeds 287 mm, suggesting that this taxon had a body mass ranging between 58 and 60 kg and making it one of the largest known troodontids. The forelimbs are surprisingly reduced. We collected measurements of the humerus, radius, metacarpals, femur, tibia, and metatarsals for a broad theropod sample including modern birds. After log₁₀ transformation of the data, we ran a PCA to evaluate morphological convergence among limb proportions across Theropoda. Our results indicate that the new specimen clusters with derived representatives of multiple coelurosaur clades with similar or higher body mass. A phylogenetically gnostic regression between PC1 scores and body mass among paravians demonstrates an inverse relationship between body mass and forelimb length in troodontids.

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

UNDERSTANDING THE PERMO-TRIASSIC MASS EXTINCTION THROUGH TETRAPOD FOSSILS FROM SOUTHERN BRAZIL

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Mass extinctions are dramatic macroevolutionary phenomena documented by the fossil record. Among the five major mass extinctions, the end-Permian extinction (EPE) is considered the largest, resulting in the mass killing of 70-90% of terrestrial and marine biota. The EPE is well-studied in Russia, China, and South Africa, but little is known about the ecological dynamics of paleocommunities in South America during this critical time interval. Although Brazilian Upper Triassic units (e.g., Santa Maria Formation) are known worldwide for bearing some of the oldest dinosaurs, there are few studies concerning strata dated from the end-Permian and Early Triassic, particularly about the EPE. Here, we assess the impact of the EPE through a comprehensive review of Brazilian continental tetrapod fossils, assessing for the first time their diversity patterns along the Permian-Triassic, as well as the effects of sampling bias. Our fossil occurrence dataset was compiled, reviewed, and corrected from the PBDB, and we included new data from the literature and museum collections. We analyzed the taxonomic diversity or richness by considering single taxa (genus and species), families, and clades - evaluating the sampling effort through species accumulation curves and diversity indices estimates in the R software. Field sampling and other analyses considering sampling bias through the shareholder quorum subsampling method are in progress. Preliminary results with raw data show the expected decrease in diversity towards the end of the Permian (corresponding to the Rio do Rasto Formation), represented by nine unique Guadalupian taxa and two ichnotaxa in the Lopingian. The Early Triassic Sanga do Cabral Formation documents an increase in diversity, but it still does not reach Guadalupian values. Taxa diversity from the Middle/early Late Triassic surpasses that of the Guadalupian and ascends even further, reaching the apex in the middle of the Late Triassic, decreasing again at the end of the Late Triassic. Our preliminary data reveal that despite the Brazilian Permian being under-sampled, about five times more taxa were missing from the Triassic. However, increasing the sampling effort for the Permian Rio do Rasto Formation and future assessments considering sampling bias will provide a weighted and more robust estimation of the diversity patterns of the continental tetrapods from southern Brazil to assess the impacts of the EPE.

Funding Sources We thank Harvard's Lemann Brazil Research Fund and Conselho Nacional de Desenvolvimento Científico e Tecnológico - CNPQ.

Technical Session 18: Birds (Saturday, November 5, 2022, 1:45 PM)

TRAIT-DEPENDENT DIVERSIFICATION IN BIRDS ACROSS THE K-PG BOUNDARY AND THE IMPORTANCE OF FOSSIL DATA

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The birds that survived the Cretaceous-Paleogene (K-Pg) mass extinction represented only a small fraction of avialan diversity in the Cretaceous. The few lineages that persisted underwent a truly exceptional radiation in the Cenozoic, becoming the most species-rich tetrapod clade today. Interrogating the factors that drive such differential survivorship and speciation is essential for understanding the origin and maintenance of biodiversity. One key hypothesis is that probabilities of extinction and speciation depend on body size, with small-bodied lineages diversifying more rapidly. However, previous tests of this hypothesis have excluded a key source of data: extinct taxa. Recent simulation studies have demonstrated that it is impossible to accurately estimate extinction rate from extant-only data. We estimated body mass in 295 extinct bird species using linear measurements of limb bones and combined these with body mass data from 9993 extant bird species. We generated an informal supertree of bird relationships incorporating all 10,288 taxa, then time-scaled the tree using the 'cal3' tip-dating method. Using quantitative state speciation and extinction modelling in RevBayes, we tested the hypothesis that small-bodied species diversify more rapidly than large-bodied species. Our models support a sigmoid relationship between body-size and net diversification rates with small-bodied lineages (e.g., Aegotheliformes, Apodiformes, Coliiformes, Galbuliformes, Passeriformes, stem-Ornithurae) diversifying approximately two times faster than large-bodied lineages (e.g., Ratites, Cathartiformes, Ciconiiformes, Dinornithiformes, Otidiformes, Sphenisciformes, Hesperornithes). This pattern is a consequence of much higher extinction rate in large-bodied species. Critically, removing extinct species from the analysis recovers a completely different pattern, with low body size correlated with low diversification rates. This adds to the growing body of evidence that models of macroevolution require the inclusion of observations from deep time. Together, these results support the hypothesis that body size was a major factor in shaping patterns of bird diversification in the Paleogene and may have influenced the differential survival of birds through the K-Pg mass extinction.

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

A NEW GNATHOSAURINE (PTEROSAURIA, ARCHAEOPTERODACTYLOIDEA) FROM THE KIMMERIDGIAN OF BRUNN, GERMANY

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Gnathosaurinae is a group with limited fossil representation amongst the Pterosauria, sparse even from prolific Konservat-Lagerstätten depositional environments, such as the Kimmeridgian–Tithonian lithographic limestones of the Solnhofen Archipelago. Their characteristic, anteriorly-expanded rostra and robust, comb-like dentitions with pronounced alveolar rims are indicative of a feeding specialization that would occupy a highly specific paleoenvironmental niche, perhaps accounting for this subsequent rarity. Recently, a dentated anterior snout fragment, including the premaxillae and parts of the maxillae, was discovered from the Late Jurassic (Late Kimmeridgian) Brunn locality, close to Regensburg (Oberpfalz), which lies along the northeastern border of the Solnhofen Archipelago region, and is the oldest locality known therein. Although the Brunn limestones have thus far yielded numerous plants, invertebrates, and fishes, terrestrial vertebrates are significantly rarer, and the locality has previously only yielded one identifiable pterosaur, the scaphognathine *Bellubrunnus rothgaengeri*, to date. The larger Solnhofen area has yielded the gnathosaurine *Gnathosaurus sublatus*, to which two specimens have been referred, however, this species differs substantially from the new specimen in its proportions, particularly in tooth morphology and spacing. Despite some similarity with *G. sublatus*, the implications of their considerable differences, coupled with the novel traits exhibited by the new specimen, such as a unique tooth enamel texture, warrants a revision of the group, since tooth texture in particular has been differentiated to a degree amongst other clades of the Pterosauria, and is found to be informative in distinguishing species. Although the specimens mentioned herein are sourced from three different stratigraphic horizons, and therefore do not necessarily co-occur, it is evident that diversity in the Late Jurassic of southern Germany is higher than previously suspected. Therefore, this new taxon not only adds yet another ecological element to the shallow marine reef environment surrounding the archipelago that has been suggested to be representative of the Solnhofen region in the Late Jurassic, but also allows for a more comprehensive understanding of the varieties of gnathosaurine dentition, contributing to the known diversity and distribution of the group worldwide.

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

URENCHELYS ABDITUS WILEY AND STEWART 1981 (TELEOSTEI: ANGUILLIFORMES) FROM THE SMOKY HILL CHALK MEMBER OF THE NIOBRARA FORMATION (UPPER CRETACEOUS: SANTONIAN) OF KANSAS, USA IS NOT A MEMBER OF URENCHELYS

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There are over 111 extant genera of anguilliform eels (Order Anguilliformes). The fossil record of anguilliform eels are represented by ten reported from the Eocene, Oligocene, and Miocene and nine described eels from the Cretaceous. *Anguillavus* is the earliest known genus, dating back to the Cenomanian. Until recently, the only known North American Cretaceous eel is *Urenchelys abditus* from the Smoky Hill Chalk Member of the Niobrara Formation (Upper Cretaceous: Santonian). Its description is based on a single specimen collected from the Hell's Bar locality in Gove County, Kansas. A second specimen was collected in 2010 from the from the Castle Rock locality of the Smoky Hill Chalk Member from Gove County, Kansas.

We re-examined the type specimen and compared it to the new specimen. We found several differences between this new specimen and the type specimen regarding tooth morphology and neural spine morphology. We also found several bones that were not in the original description of the type. Furthermore, bones originally described in the type specimen as the upper jaw were reinterpreted as bones belonging to the suspensorium.

A phylogenetic analysis consisting of 39 taxa and 123 characters was made. The taxa included extant species, Cenozoic fossil species, and Cretaceous species. A strict consensus of 27 trees showed that whereas both the type specimen and this new specimen are sisters, they are paraphyletic with respect to the *Urenchelys*. We tentatively accept that the two Kansas specimens are of the same species, however, they are not members of *Urenchelys*.

Technical Session 10: Soft Tissues & Taphonomy (Friday, November 4, 2022, 8:00 AM)

OUTSTANDING THREE-DIMENSIONAL PRESERVATION OF BRAINS AND CRANIAL NERVES IN LATE PALEOZOIC STEM ACTINOPTERYGIANS

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The lack of information on soft-tissue anatomy for extinct species contributes to a gap between paleontology and neontology. Rare information provided by exceptional preservation is a unique source of direct (rather than inferential) information regarding patterns of evolution of soft tissues through geologic time. Problems arise as instances of exceptional preservation are sometimes overlooked, and their interpretation might be challenging due to taphonomic alteration and lack of comparative data. Here we present novel information on the brain anatomy of early ray-finned fishes

based on three-dimensional soft-tissue preservation in six specimens representing at least two different species from the Permo-Carboniferous of Brazil. Osteological data indicates both are stem-group actinopterygians. The putative examples show clear characteristics of vertebrate brains including forebrain, midbrain, hindbrain, associated cranial nerves, and meningeal tissues. Gross morphology of these fossil brains agrees with the expectations for early ray-finned fish brain anatomy, based on data from extant non-teleost ray-finned fishes. Features include a well-developed optic tectum, robust trigemino-facial nuclei, and a poorly developed corpus cerebelli. However, these fossils show features typically thought to have emerged in more nested clades, challenging current interpretations of ray-finned fish brain evolution. This includes a distinct hypothalamic inferior lobe, which is restricted to actinopteran (i.e., crown ray-finned fishes to the exclusion of polypterids) among living species. Other unexpected characteristics concern variation in the complexity of rhombencephalic meningeal tissues. Most appear like those of *Polypterus*, but one specimen shows a well-developed myelencephalic gland similar in shape and positioning to that of holosteans in general and *Lepisosteus* in particular. Other similarities to *Polypterus* include the absence of intraventricular projections (e.g., torus longitudinalis and semicircularis) within the mesencephalon, which are only known in extant actinopterans. Our results demonstrate that these fossil brains exhibit a mosaic of characteristics expected for early ray-finned fishes. However, unexpected features more closely resembling actinopterans challenges the use of *Polypterus* as a model for early ray-finned fish brain evolution.

Funding Sources University of Michigan Department of Earth and Environmental Sciences

Preparators' Session (Thursday, November 3, 2022, 8:00 AM)

BASIC FIELD JACKETING TECHNIQUES - A CASE STUDY OF METHODS USED IN THE NIOBRARA FORMATION OF KANSAS

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Field jackets are a critical component to the work of paleontologists and preparators. They ensure safe transport of fossil material from the field to the lab, and safe storage once there. Triebold Paleontology Inc. (TPI) has completed fieldwork for over three decades and has honed an effective set of methods for field jacketing that will be used to discuss basic techniques and safety. Topics include materials, personal protective equipment, overall plan for jacket size, shape, structure, flip, and safe extraction. The aim of testing different field jacketing methods is to provide anyone doing fieldwork with a basic set of guidelines to recover specimens in the

safest way possible. Standardizing field collection techniques has the potential to improve the science of paleontology as a whole.

The authors investigated how jacket strength may be affected by different fabrication methods. Strength tests were performed on strips made using three layers of 45 cm x 15 cm burlap and USG Hydrocal White Gypsum Cement. Four different methods were tested: 1) Hydrocal was mixed normally (control); 2) the strip was sprayed with water after the Hydrocal had set but not fully cured; 3) Hydrocal was allowed to partially set and thicken, then water added to thin it to working consistency; 4) burlap was soaked in water before use. Each strip was placed on a scale and tested to failure. The control and the strips sprayed with water failed at approximately the same amount of weight whereas the strips made with reconstituted plaster and wet burlap failed earlier. These results indicate that constructing field jackets using water-soaked burlap or reconstituted plaster are inferior techniques.

Additional tests examined whether burlap cut on the bias or parallel to the weave (straight-cut) affects overall jacket strength. Three layers of bias-cut burlap laid in alternate orientations to create a woven square were mixed with Hydrocal and then tested to failure against squares with straight-cut burlap. Results show that squares made with straight-cut strips failed at approximately half the weight as the bias-cut squares. The authors also tested this idea using simulated standardized jackets, tested after 3 days (short-term cure to simulate field conditions) and after 30 days (long-term cure to approximate storage). These results show that straight-cut jackets failed under less weight as well as more catastrophically than bias-cut jackets.

Funding Sources This investigation was funded through day to day TPI business activities.

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

A JUVENILE SPECIMEN OF THE ORNITHOPOD DINOSAUR *TENONTOSAURUS* FROM THE LOWER CRETACEOUS OF MONTANA, U.S.A.

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Tenontosaurus is an iguanodontian dinosaur known from a few Lower Cretaceous formations across the western and southern United States. The genus is represented by over 300 specimens spanning a wide range of ontogenetic stages, but perinates and juveniles are rare. *Tenontosaurus* is thought to grow rapidly for its juvenile phase, followed by an extended period of modest growth approaching adulthood. Here we describe a new partial skeleton of a small *Tenontosaurus* individual from the Kootenai Formation of

southern Montana. Both and postcranial remains are preserved, including parts of the forelimb, hindlimb, skull, vertebral column, and dorsal ribs. Dentigerous elements exhibiting tooth replacement are present. Neurocentral and some cranial sutures are unfused, and skeletal elements average only about one-third the size of the largest known *Tenontosaurus* individuals, suggesting that this individual represents a young juvenile. Little ontogenetic variation is apparent in the autopodial elements or teeth, whereas dorsal vertebrae are substantially more elongate than those of older individuals. Few tendons are preserved, suggesting that these remained unossified until later in life. This new specimen represents a rarely preserved ontogenetic stage for *Tenontosaurus*, with potential to elucidate aspects of growth and life history within the genus.

Technical Session 16: Hoofed Mammals (Saturday, November 5, 2022, 8:00 AM)

TOTAL EVIDENCE PHYLOGENETIC REASSESSMENT OF THE ENIGMATIC *MACHAEROMERYX TRAGULUS* (ARTIODACTYLA, RUMINANTIA) FROM UPPER HARRISON (LOWER MIOCENE) OF NEBRASKA

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Machaeromeryx tragulus, an extinct ruminant featuring drastically enlarged canines and lacking cranial appendages, is known primarily by one specimen: a nearly complete skeleton from the Lower Miocene first described in 1926. Originally placed within Cervidae despite also being described as a traguloid, more recent research has reassigned *Machaeromeryx* to the family Moschidae, citing similarities to *Blastomeryx*. In the almost hundred years since its discovery, *Machaeromeryx tragulus* has not been included in any phylogenetic analyses, obfuscating its evolutionary relationships in Ruminantia. Fossil specimens can easily be placed within families if cranial appendages are preserved, however those without—including females and members of Tragulidae and Moschidae—require more thorough examination of a suite of traits. To address the lack of phylogenetic analyses for this species, we test the hypothesis that *Machaeromeryx tragulus* is a moschid using Bayesian and maximum likelihood analyses of a total evidence matrix comprised of 11 extinct and 9 extant taxa spanning Moschidae, Tragulidae, Antilocapridae, Giraffidae, Palaeomerycidae, Cervidae, and Bovidae. Of 68 morphological characters compiled for all taxa, we recorded 40 for *Machaeromeryx tragulus*, while mitochondrial genomes for all extant species provide molecular data. Additional parsimony analysis was conducted using morphological characters. Morphological evidence does not support inclusion of *Machaeromeryx tragulus* in Moschidae, nor does it support inclusion in Tragulidae, Cervidae, or Bovidae. All analyses position *Machaeromeryx tragulus* within infraorder Pecora,

however outside of both Cervoidea and Bovoidea, notably similar to recent reevaluations of *Blastomeryx*. This placement could imply another example of secondary loss of cranial appendages—as suggested in moschids and some cervids—or a more complex scenario where early pecorans lacking appendages persisted for some time while other families acquired their adornments.

Technical Session 10: Soft Tissues & Taphonomy (Friday, November 4, 2022, 8:00 AM)

DESCRIPTION OF A SKIN IMPRESSION OF A DIPLODOCID SAUROPOD FROM DINOSAUR NATIONAL MONUMENT (TITHONIAN), MORRISON FORMATION, USA

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Carnegie Museum of Natural History (CM) specimen 41682 consists of series of dorsal vertebrae, some fragments of dorsal rib, and other small elements belonging to a juvenile sauropod dinosaur, assigned tentatively to *Apatosaurus*. During preparation, a small, subtriangular skin impression 12 cm long by 5 cm wide at the base was found, preserving at least 32 individual scales. This specimen represents the second sauropod skin impression record from Dinosaur National Monument and the fifth from the Morrison Formation overall. The texture of the impression is friable, fine-grained sandstone with a pale, grayish-white color. The scales are of the basement type, asymmetric polygonal (mostly hexagonal), sub-rounded, and with a diameter that varies from 1 to 1.5 cm. Towards the base and towards the narrowest part of the patch, irregular scales are observed with a fuzzy margin, and occasionally radial striae. There is no apparent pattern or arrangement, the scales are more or less evenly distributed. The superficial papillae appear as small convex protuberances of about 0.5 to 3 mm, reminiscent of the Argentine sauropod *Tehuelchesaurus benitezii* (MPEF-PV 1125/1) and the North American diplodocid *Diplodocus* sp. (CMC VP8075). The quality of preservation is variable. Towards the extreme left of the base and in the narrower upper region of the patch, scales are hardly noticeable and the papillae appear flattened. This could be due to erosion produced by the impact of sediment particles at the exposed ends of the patch, which, within the cast-jacket, was found with the surface of the scales facing the vertebrae.

The associated vertebrae have the same grayish-white, medium to coarse-grained sandstone matrix with the exception of one element that was preserved similar to the skin fragment, with a friable much finer-grained sandstone of a lighter color. We infer the proximity to a channel and a high-energy flow capable of depositing coarse-fractional materials and the subsequent stabilization of the system by depositing finer materials.

It is remarkable that few skin sections exist in the record that are reliably associated with the bones to represent their natural positions. According to the position in which the materials of specimen CM41682 were found and its subsequent analysis, we consider that the small skin impression represents the region near the forelimb of the animal. Further preparatory work on the vertebrae will clarify the taxonomic assignment of the specimen.

Technical Session 13: Early Archosaurs & Pterosaurs (Friday, November 4, 2022, 1:45 PM)

ORIGINS OF PTEROSAURIA: HIDDEN FOSSIL RECORD AND NEAR EXTINCTIONS OF THE FIRST AND LONGEST-LASTING FLYING VERTEBRATE LINEAGE REVEALED THROUGH A NEW PHYLOGENETIC HYPOTHESIS

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Pterosaurs were prominent members of Mesozoic faunas, existing throughout the period to its end as one of or the primary aerial vertebrate clade. Survival across major biotic transitions (eg. mass extinctions) and the origins of pterosaurian diversity are important for understanding their morphological and flight evolution. Debate exists as to whether Triassic and Jurassic pterosaurs represent larger, monophyletic subclades or a series of successive sister taxa to Monofenestrata (pterodactyloids and pterodactyloid-like forms). Reexamination of early ornithomirans and of the 'eudimorphodontoid' pterosaur *Arcticodactylus cromptonellus* show a mosaic of lagerpetid and pterosaur features. Notably, *A. cromptonellus* lacks features diagnostic to the rest of Pterosauria while possessing features apomorphic of the Triassic-endemic pterosaurian Eudimorphodontoidea and/or Raeticodactylidae, suggesting the paraphyly of this subclade(s) to later pterosaurs. To resolve this possible paraphyly, we have assembled a new phylogenetic dataset representing a concatenation of existing pterosaur phylogenetic analyses, revised characters, character states, and scores and include new characters from across the skeleton and a comprehensive sampling of archosauriforms (including all lagerpetids), all pterosaurs from the Triassic-early Jurassic, and a representative sampling from the middle Jurassic-Cretaceous. We found a ladder-like grade in which few pterosaurs form side branches to the exclusion of middle Jurassic-Cretaceous pterosaurs. Eudimorphodontoidea/Raeticodactyloidea, Dimorphodontidae, and Scaphognathidae/Rhamphorhynchidae are recovered as

respectively paraphyletic to each other and Monofenestrata, decreasing or eliminating many early pterosaur ghost lineages. We find only a single pterosaur lineage crossed the Triassic-Jurassic and Early-Middle Jurassic biotic transitions, the former of the 'dimorphodontid' grade (large-headed terrestrially adept forms) and the latter of the 'rhamphorhynchid/scaphognathid' grade (aerial predators). These results demonstrate a clear loss of diversity in early Pterosauria (here approaching extinction) with the loss of all but one pterosaur lineage akin to losses found in other groups that crossed the end Triassic and Early-Middle Jurassic biotic transitions into the late Mesozoic.

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

ADDITIONAL SKULLS OF *BATHYOPSIS* (MAMMALIA, DINOCERATA) FROM THE BRIDGER BASIN, WYOMING AND THEIR IMPLICATIONS FOR SPECIES VARIATION WITHIN *BATHYOPSIS*

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Bathyopsis is a relatively small uinatheriid recognized from the early to earliest middle Eocene of Wyoming and Colorado. The genus is less-well known compared to its larger middle Eocene relative *Uinatherium*. *Bathyopsis* is characterized as the plesiomorphic sister-taxon, half the size of the larger terminal uinatheres. The skull of *Bathyopsis* possesses rudimentary osseous horn-like protuberances, early structures of the horns that notably crown the skulls of the larger middle Eocene uinatheres. Two species are typically recognized within the genus. *Bathyopsis fissidens* was originally described from a lower jaw discovered within the Wind River Basin, Wyoming. A skull from the same area was later tentatively assigned to this species. Decades later, an additional skull was described from the early Bridgerian (early to middle Eocene) of the Bridger Basin, Wyoming. This skull was assigned to *Bathyopsis middleswarti* based upon its larger size, broad occiput, and increased horn development. The validity of two species of *Bathyopsis* has been questioned, as the defining characters may be sexually dimorphic. Herein, two additional *Bathyopsis* skulls (UW 2248 and 3037) are described. Both skulls are from the Bridger Basin and are assigned to the genus *Bathyopsis middleswarti*. The additional skulls reveal more characters unique to *Bathyopsis middleswarti*. These include: the presence of well-developed nasal protuberances, anteroposterior elongation of the premaxillae, transversely expanded parietals on the dorsal side, and maxillary protuberances located anteriorly of the diastema constriction. The skulls of both species have relatively large, well-developed, canine saber tusks. As canine size is thought to be a significant indicator of sexual dimorphism in uinatheres, there is no clear indication of sexual dimorphism accounting for the differences between *B. fissidens* or *B. middleswarti*. The three skulls of *B.*

middleswarti reveal potential sexual dimorphism that accounts for a 10% size discrepancy between the smallest and largest skulls of the species. The additional skulls support the identification of two species of *Bathyopsis*. *B. fissidens*, a smaller form known from the early Eocene and *B. middleswarti*, a 25% to 40% larger, early to earliest middle Eocene form, with more developed horn protuberances and greater anteroposterior elongation of the skull trending towards the condition of *Uintatherium*.

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

IDENTIFICATION OF THE PLEISTOCENE FAUNA FROM MCFADDIN BEACH, TEXAS

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McFaddin Beach is an archeological (41JF50) and paleontological locality extending approximately 32 kilometers along the eastern coastline of Jefferson County, Texas. Fossils and artifacts have been washing ashore from an unknown location(s) since Hurricane Carla made landfall in 1961. The presence of taxa such as *Bison* indicate that there are some Rancholabrean fauna of late Pleistocene in age at this site. However, due to the unknown source deposits or number of deposits, not all material that washes ashore on McFaddin Beach can be attributed to a Rancholabrean fauna. The location of the deposit(s) is hypothesized to be on the Texas-Louisiana continental shelf near the relic river valleys of the Trinity, Sabine, Neches, and Calcasieu rivers which would have been above sea level at various times throughout the Pleistocene. The McFaddin Beach material is scattered into many small collections throughout Texas. The Pleistocene fauna from this site has only been described in one study done by a master's student at Lamar University in 1975. In recent years, several collections were acquired by Sam Houston State University and are held at the Sam Houston State University Natural History Collections. We reassessed all accessible institutionalized McFaddin Beach collections from Sam Houston State University, the vertebrate paleontology collections at The University of Texas at Austin, and the Museum of the Gulf Coast. A total of 40 taxa were identified at McFaddin Beach, both in the institutionalized collections and those previously reported in the 1975 unpublished thesis. The taxa consist of one crustacean, four fish, seven reptiles, and 28 mammals. These collections contain many taxa common through the Pleistocene, such as *Holmesina*, *Bison*, *Mammuthus*, and *Mammut*. Some uncommon taxa also are present, including Tapiridae, *Eremotherium*, *Trichechus manatus bakerorum*, *Homotherium serum*, and *Callinectes*. The latter three taxa have been recently reported to be found at

McFaddin Beach. The fossil material assigned to *Trichechus manatus bakerorum* is the first ever recorded in the Pleistocene of Texas. The material assigned to *Homotherium serum* extends by more than 300 km the known range of that species to the Coastal Plain of Texas. Fossil material assigned to the genus *Callinectes* is the only crab ever recorded at McFaddin Beach. These taxa further distinguish the McFaddin Beach locality from other nearby localities of similar age.

Symposium: A Late Miocene Shangri-la (Wednesday, November 2, 2022, 1:45 PM)

THE SHUITANGBA MICROFAUNA: A LATE MIOCENE WINDOW TO AN INDOMALAYAN WETLAND COMMUNITY

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Shuitangba (STB) small mammal fossils recovered by excavation and screening over several field seasons represent a diverse assemblage that is distinct from coeval microfaunas of North China, but very much like the slightly older, better-known fauna of Lufeng, Yunnan. Among about 150 recovered specimens, thirteen insectivorans, rodents, and a rabbit represent upland, moist habitat. These include a gymnure hedgehog and an extinct mole. There are at least two shrews, including *Anourosorex*, the extant species of which occurs in upland forests of about 1500 to 3000 m elevation. The rabbit is an early member of the living nocturnal genus *Nesolagus* of upland forests. At least eight rodents are represented variously by isolated teeth recovered through screening or as more complete cranial fossils from excavation. Two squirrels include the terrestrial rock squirrel *Sciurotamias* and a larger flying squirrel. A few isolated teeth represent the primitive hamster *Kowalskia*. There are at least two mice, a smaller species of *Linomys* and a larger rat-sized genus. Many specimens of a large beaver recovered primarily by excavation comprise both immature and adult individuals. This beaver dominated the small mammal wetland community, and is larger than the slightly older Lufeng beaver, but much larger than the middle Miocene *Steneofiber siamensis* from Thailand. The STB beaver is an end member of an Asian lineage of extreme southern distribution. Two species of bamboo rats complete the assemblage recovered to date. One is a low-crowned species very much like a Lufeng *Miorhizomys*. The other, a much larger *Rhizomys* with very high-crowned teeth shows diversity in exploiting the subterranean habitat. That

habitat was a wetland of perhaps 2000 m elevation (as Zhaotong is today), and not a featureless swamp. Being subterranean, bamboo rats require up to 50 cm above the water table for the burrow system.

Funding Sources Fieldwork was supported by USNSF, the Yunnan Natural Science Foundation, the Government of Zhaotong, and IVPP through the National Natural Science Foundation of China.

Technical Session 13: Early Archosaurs & Pterosaurs (Friday, November 4, 2022, 1:45 PM)

CLIMATE DRIVERS OF EARLY PTEROSAUFOMORPH EVOLUTION

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Pterosaurs were the first vertebrates to evolve powered flight and were major components of Mesozoic terrestrial ecosystems. However, their origin is still poorly understood, due to a stratigraphic and morphological gap between these reptiles and their closest relatives, the lagerpetids. Although pterosaurs and lagerpetids had extensive stratigraphic overlap during the Norian–Rhaetian, their geographic co-occurrences are limited, suggesting that global climatic conditions may have played an important role in early pterosaufomorph evolution and biogeography. In order to test this hypothesis, we assembled a specimen-based dataset of Triassic pterosaufomorphs using the Paleobiology Database (www.paleobiodb.org), updated with the most recent literature. We first examined the global distributions of Triassic pterosaufomorphs using a time-dependent probabilistic historical paleobiogeography (BioGeoBEARS) approach, and a novel tip-dated maximum clade credibility tree as a phylogenetic framework. We then investigated the climate conditions occupied by pterosaurs and lagerpetids by integrating both group’s occurrence data with paleoclimate climate information from a Atmosphere–Ocean General Circulation Model (HadCM3L-M2.1). We found that these clades exhibit only minimal overlap in geographic range and climate niche: lagerpetids have a wider geographical spread, perhaps enabled by a higher tolerance for temperature fluctuations and a preference for the drier environments, more common in the Middle–early Late Triassic; by contrast the

earliest pterosaurs primarily occupied the low-latitude regions of the Northern Tethyan gulf that, following the Carnian Pluvial Event, were humid and less subject to severe temperature fluctuations. The sudden and relatively localized radiation of the first pterosaurs in the middle Norian followed the arrival of lagerpetids in the tropical belt, and both of these events might have been favored by the removal of lower latitude climatic barriers. The successive biogeographic expansions of these groups occurred in concert with the onset of favorable climatic conditions in equatorial regions and in South America. Based on these results we conclude that a major pulse of environmental change, resulting from shifts in CO₂ and/or palaeogeography in the early Late Triassic, likely acted as a significant driver in the early evolution of one of the most successful clades of Mesozoic vertebrates.

Funding Sources This study was supported by the Royal Commission for the Exhibition of 1851 (DF) and by Leverhulme Research Project Grant (RPG-2019-365) (RJB, EMD, AF, DJL, and PJV).

Colbert Prize Session

DISTINCT LINEAGE-SPECIFIC DEVELOPMENTAL TRAJECTORIES UNDERLIE BRAIN SHAPE DIVERSIFICATION IN RATITES (AVES: PALAEOGNATHAE)

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How do disparate brain shapes evolve? Comparative neuroanatomical studies have proposed that divergent brain morphologies could evolve from species-level differences in size along shared brain-to-body-size scaling relationships and/or evolution of lineage-specific allometric trajectories. For example, neuroanatomical diversification among non-avian and avian dinosaurs could potentially be attributed to size differences. Understanding the relative contributions of these mechanisms requires a comparative sampling of intraspecific allometric trajectories. While developmental series of non-avian theropod brains are rare in the fossil record, studying the brains of close, extant relatives such as palaeognaths, a group of primarily large-bodied flightless birds, may shed insight into how this evolutionary divergence was achieved. In this study, we use a unified framework to examine brain development in ratites, which can attain large body sizes as adults (~60kg), compared to domestic chickens, a taxon with more modest adult body size (~5kg) among modern birds. We utilize a high-density 3-D geometric morphometric approach on endocasts from micro-CT data of late- and post-embryonic specimens of common ostriches (*Struthio camelus*; n = 14), emus (*Dromaius novaehollandiae*; n = 14), and southern cassowaries (*Casuarius casuarius*; n = 18). Then, we compare their developmental trajectories and shape differences with

those of domestic chickens (*Gallus gallus*; n = 14). We find that 1) chickens and ratites have distinct brain shapes; and 2) chickens and ratites consistently have distinct developmental trajectories regardless of whether endocranial size or temporal age are used as independent variables. Our results show that chickens and ratites have different brain shapes which come about through different developmental trajectories. This may potentially arise from differences in neurogenic patterns. Furthermore, our study suggests that major differences in brain shape between differently-sized taxa can arise from evolution of unique developmental trajectories, instead of simply as an extension of a conserved ontogenetic trend. The results establish a working hypothesis for whether other dinosaurs, including non-avian theropods, may have also acquired different brain shapes from their closest relatives through similar means.

Funding Sources Laidlaw Scholarship & Columbia Travel Grant (MF); National Science Foundation MRI 1450850, 1457180, 1725925, & 1754659 (PG); Western Interior Paleontological Society (TG)

Technical Session 3: Marine Reptiles (Wednesday, November 2, 2022, 8:00 AM)

RELATIVE SWIMMING BURST CAPABILITIES IN MOSASAURS: INSIGHTS INTO MOSASAUR ECOLOGY AND EVOLUTION

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Mosasaurs are great models for reconstructing the aquatic locomotion of fossil animals because they are often well-preserved with most skeletal elements and soft tissue preservation like skin, cartilage, and impressions showing limb and tail outlines. Mosasaurs were the dominant marine reptiles of the Late Cretaceous and are an important clade to reconstruct comprehensive, whole body functions for as they relate to ecology and evolution. Due to their preservation, reliable reconstructions of mosasaurs can be made, and they are the only extinct Mesozoic marine reptile clade to have a wide assemblage of extant relatives (lizards) of which to draw anatomical comparison from for reconstruction purposes. Herein we determined relative burst performance of mosasaurs that span the mosasaurine and ‘russellosaurine’ sides of mosasaur phylogeny. Burst is a key locomotory behavior that is relevant to prey capture and can assist in interpretation of an animal’s ecological placement. For mosasaurs, burst potential can reveal how mosasaur ecology may have changed through their evolution. For selected mosasaurs, lateral and dorsal reconstructions and mass estimations were made, as well as

reconstructions of tail cross sections near the base of the tail and just prior to the caudal fluke to determine caudal muscle volume. Muscle volume was used to estimate total muscle power to calculate the propulsive force that a mosasaur tail could exert over the amplitude and time that the tail would be displaced, and then determine relative exit velocity of a mosasaur based on the drag equation. Our findings show that the relative exit velocities of mosasaurs in a “fast-start,” drag-based burst are most impacted by the lateral tail excursion arc length and the speed at which the tail is released. *Platecarpus*, a ‘russellosaurine’ and relatively smaller-bodied mosasaur, showed the highest burst potential with an exit velocity that was 4.2 times greater than the stouter-bodied mosasaurine *Prognathodon*, and approximately 3.4 times that of the mosasaurine *Plotosaurus*, and *Tylosaurus* a ‘russellosaurine.’ Of the mosasaurines, *Plotosaurus* indicated a slightly higher initial burst potential than *Prognathodon*. These results suggest that smaller, less aquatically specialized mosasaurs relied more on bursting than larger, more specialized mosasaurs. However, all mosasaurs showed potential for high burst speeds, including *Plotosaurus*, considered the most derived mosasaur and a ‘cruiser.’

Technical Session 20: Crocodylomorpha (Saturday, November 5, 2022, 1:45 PM)

BIOMECHANICS OF ALLIGATOR INTRAMANDIBULAR JOINTS AND ITS SIGNIFICANCE TO THEROPOD DINOSAURS

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The sauropsid mandible is a complex compound element formed by rostral (dentary, supradentary, and splenial) and caudal (coronoid, surangular, angular, prearticular, and articular) elements separated by a prominent intramandibular joint (IMJ), whose effect on feeding performance is speculative. Non-avian theropod dinosaurs possess thin and narrow hemimandibles with superficially hinge-like, unbuttressed IMJs suitable for resisting dorsoventral bending, but hypothetically susceptible to mediolateral bending at the IMJ. Non-avian theropod IMJs are also hypothesized to have been a zone of compliance wherein feeding stresses were absorbed as elastic potential energy within the sutural ligament. In order to assess the IMJ’s effect on mandibular performance, *Alligator* mandibles were separated from their crania and CT-scanned. The IMJ’s articular surface area was determined via segmentation of CT data, and its complexity assessed with morphometrics. Each hemimandible’s mechanical properties were determined by embedding them in epoxy and attaching strain gauges to the dentary, angular, and surangular, then bending the mandibles about the dorsoventral and mediolateral planes. Values for individual muscle orientation and force were taken from alligators of comparable size described in the literature. We find that IMJ articular surface area and complexity increase allometrically through

ontogeny with bite force, but increases in IMJ surface area occur primarily along the horizontal plane. Dorsoventral bending stress and strain magnitudes posterior to the IMJ meanwhile are comparable to predictions from calculated IMJ surface areas. Mediolateral component of the temporal musculature progressively increases through ontogeny, but mediolateral bending stress and strain magnitudes posterior to the IMJ are higher for the most mature specimens than predicted for their calculated IMJ surface area. Our results suggest that the IMJ is a zone of compliance susceptible to bending in archosaur mandibles, with the bending direction depending on how forces are oriented with respect to the IMJ's sutural surfaces. *Alligator's* telescoped IMJ sutures are well suited to dissipate dorsoventral, but less so mediolateral, bending stresses. However, non-avian theropod IMJs have less sutural contacts, and their pterygoids far less robust, than extant crocodylians; their tall and narrow hemimandibles were therefore far more susceptible to mediolateral or torsional forces.

Technical Session 9: Mammals (Friday, November 4, 2022, 8:00 AM)

QUANTIFYING ESTIMATES OF C₄ FRACTIONS IN DIETS AND PALEOSOLS USING A COMPILATION OF PLANT $\delta^{13}\text{C}$ VALUES AND A MONTE CARLO MODEL TO PROPAGATE UNCERTAINTIES

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Stable carbon isotope analyses of bioapatite and paleosols have become standard methods in mammalian paleoecology, particularly for (but not limited to) studies focused on the history of C₄ grasses. C₄ photosynthesis evolved multiple times among grasses beginning in the Paleocene, but ecosystems dominated by C₄ grasses that comprised substantial components of mammalian diets only appeared in the late Cenozoic. Quantitative interpretation of $\delta^{13}\text{C}$ values of bioapatite or paleosols in terms of dietary or habitat fraction of C₄ biomass (f_{C_4}) requires assignment of end-member $\delta^{13}\text{C}$ values for C₃ and C₄ plants, fractionations associated with transformation of atmospheric CO₂ to bioapatite and paleosol organic matter and carbonate, and the $\delta^{13}\text{C}$ of atmospheric CO₂ in the past. However, physiology and environmental conditions impart substantial variation on plant isotopic compositions, more so for C₃ than for C₄ plants, and the other parameters are known or estimated with quantitatively important uncertainty. Consequently, detection of diets and/or habitats with low f_{C_4} is difficult and estimates of f_{C_4} even for high C₄ abundance is sensitive to assumptions and often done without propagation of uncertainties. Here we present a new compilation of published plant $\delta^{13}\text{C}$ values and use those in a Monte Carlo model to estimate f_{C_4} from $\delta^{13}\text{C}$ values of tooth enamel and paleosols while propagating all uncertainties,

including analytical precision and sample heterogeneity. The compilation currently includes 2,809 $\delta^{13}\text{C}$ values (>70% for individual plants) and can be filtered by taxonomy, leaf habit, growth form, photosynthetic pathway, geography, climate, and biome so a priori knowledge for a locality (e.g., estimated mean annual precipitation from ecometrics or paleosol chemistry) can be used to constrain data distributions within the Monte Carlo model. An advantage of this method is that it allows for statistical assessment of whether or not a measured $\delta^{13}\text{C}$ value of bioapatite or paleosol organic matter or carbonate likely indicates the presence of C₄ biomass. Applying this approach to data from Miocene and Pliocene sites that document stages in the C₄ transition in North America (e.g., Coffee Ranch, TX, ca. 6.6 Ma) and eastern Africa (e.g., Aramis, Ethiopia, 4.4 Ma) resulted in very large but realistic uncertainties in f_{C_4} estimates. We argue that the Monte Carlo approach is an improved method for reporting f_{C_4} and will help in ongoing paleoecological reconstructions.

Technical Session 4: Paleobiogeography (Wednesday, November 2, 2022, 1:45 PM)

POST-EOCENE RHINOCEROTID DISPERSAL VIA THE NORTH ATLANTIC

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Biotic interchange (i.e., the movement of organisms among regions and continents) among Europe, Asia and North America over the last 66 Ma shaped biodiversity on all three continents. However, for most clades, the number and timing of dispersals remain poorly understood. Herein, we aim to reconstruct the biogeographic history of rhinocerotids, a Cenozoic mammal clade with considerable past diversity and a geographic range that encompassed much of the globe. Using a fossilized birth-death approach, we estimate the largest, time-calibrated phylogeny of Cenozoic rhinocerotids, to date. We then use the maximum likelihood approach in BioGeoBEARS to fit an array of biogeographic models (e.g., Dispersal – Extinction Cladogenesis (DEC), DEC plus jump dispersal) and stochastic character mapping to infer the number of biotic interchange events among Asia, Europe, North America, the Middle East, and Africa. We find that the highest rates of biotic interchange for rhinocerotids, unsurprisingly, occurred between Europe and the Middle East and Europe and Asia. However, the next highest number of exchanges occurred between Europe and North America. Furthermore, we show that dispersal between Europe and North America occurred as late as the Miocene, suggesting the North Atlantic route may have been passable for mammals millions of years longer than previously proposed; typically, the North Atlantic route has been considered passable only from the Paleocene to the end of the Eocene. Recent

geological evidence, however, suggests that there was no deep water exchange between Arctic – Atlantic oceans via the Fram Strait until the early Miocene, thus implying that the De Geer dispersal route (i.e., via the Barents Sea and Greenland) may have been passable. We therefore hypothesize that Rhinocerotid dispersal between Europe and North America through the Oligocene and the earliest Miocene may have occurred via the North Atlantic. Our study reveals the complex history of the Rhinocerotidae and provides insight into the importance of the Arctic as a persistent connector of otherwise geographically disparate faunas.

Funding Sources Discovery Grant Program, Natural Sciences and Engineering Research Council of Canada

Technical Session 1: Dinosaurs (Wednesday, November 2, 2022, 8:00 AM)

TOOTH BREADTH EVOLUTION WITHIN SAUROPODOMORPHA AND IMPLICATIONS FOR TAXONOMIC IDENTIFICATION OF ISOLATED TEETH

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Sauropod teeth are commonly categorised taxonomically by slenderness index (SI; apicobasal height/mesiodistal length) which quantifies breadth, and compression index (CI; labiolingual width/mesiodistal length) which quantifies cross-sectional circularity. SI values <4 represent broad crowns (e.g., *Camarasaurus*) and >4 represents narrow crowns (e.g., *Diplodocus*). CI has been mostly used to distinguish between tooth morphotypes observed in titanosaurs. Although both indices are used to infer high-level taxonomic affinities, little is known about the linear relationships between the constituent measurements or how the indices vary intra-cranially (e.g., tooth position, jaw type) and at lower taxonomic levels. Here, we evaluate these relationships using a novel dataset of sauropod teeth (N=976) spanning all major sauropod groups.

Results indicate significant differential scaling within Sauropodomorpha for both indices, both in slope and elevation (SI; $R^2 = 0.65$, $p = <2.22e^{-16}$, CI; $R^2 = 0.82$, $p = <2.22e^{-16}$). Broad-crowned sauropods mostly display positive allometry in SI compared to isometry in narrow-crowned sauropods. However, this distinction is less clear with CI as most sauropods display isometry, whilst non-sauropod sauropodomorphs (e.g., Plateosauridae) display positive allometry. An ANOVA reveals SI varies significantly with genus and tooth position ($p = 0.001$). Specifically, jaw type (maxilla and dentary) is significant within Plateosauridae, whilst tooth position is significant within titanosaurs. Overall, variation within CI is restricted to genus ($p = 0.001$). However, some taxa exhibit significant variation based on tooth position (e.g., *Bajadasaurus*), and even some evidence

for sidedness (e.g., *Issi*).

Whilst indices have taxonomic utility, there are caveats. The measurements used to calculate the indices exhibit significant allometry, indicating that index values are size-dependent. Furthermore, the indices may not accurately reflect heterodont conditions present among early-branching sauropodomorphs. The differences between these taxa and titanosaurs may represent the shift towards anterior-packing of teeth that potentially coincide with bulk-feeding and larger body sizes. Our study highlights the importance of quantifying taxonomic relationships of measurement data within an allometric and multi-factor framework, which can be used to inform hypotheses regarding the physiological and paleoecological drivers influencing shape variation.

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Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

NEW CRANIODENTAL MATERIAL OF THE THERIZINOSAURIAN *FALCARIUS UTAHENSIS*

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Therizinosaurian cranial materials are rare and thus far, complete skulls are described for only two taxa—*Jianchangosaurus* and *Erlikosaurus*. This scarcity has long hampered our ability to reconstruct the interspecific evolutionary relationships of therizinosaurians and assess intraspecific ontogenetic and individual variation. Recent excavations have yielded multiple new craniodental remains attributable to the early-branching therizinosaurian *Falcarius utahensis* from the Berriasian-Valengianian lower Yellow Cat Member of the Cedar Mountain Formation (Utah, USA). This material, which includes new elements (isolated fused parietals, an articulated frontoparietal complex, and an isolated right squamosal) and additional specimens of previously known elements (e.g., frontals, postorbitals, quadrates, dentaries, and teeth), provides novel phylogenetic information and the chance to assess variation in this taxon.

A sagittal crest is present, as in other coelurosaurians and in contrast to later-diverging therizinosaurians. There is a pronounced subtriangular concavity on the postorbital process of the frontals emarginated rostrally by a sharp ridge marking the rostral rim of the supratemporal fossa that is not observed on other therizinosaurians. The triradiate squamosal shares a caudally extended contact with the postorbital (which terminates dorsal to the prequadratic process) with other

therizinosaurians, yet differs in bearing an acute ventral notch between the prequadratic and caudal processes, a distinct lateral fossa on the prequadratic process, and in lacking a dorsally elevated, robust parietal process. Many features of previously known elements are consistent across additional specimens (e.g., morphology of quadrate body and mandibular capitulum; gently arched postorbital with ovoid laterosphenoid facet; absence of lateral shelf and downturned symphysis of dentaries; elongated, cupped, adenticulate rostral teeth) reaffirming their taxonomic utility and supporting the phylogenetic position of *F. utahensis* as a primitive therizinosaurian. Continued collection and preparation of *F. utahensis* cranial materials will allow for a deeper understanding of variation and the potential paleobiological and systematic implications for this important taxon.

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Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

A REVIEW OF THE CAMELIDS (TYLOPODA, MAMMALIA) FROM THE JUNTURA FORMATION (MIOCENE) OF EASTERN OREGON

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The Juntura Formation is Clarendonian in age and was originally collected by the University of Oregon in the 1950's and 1960's. It was postulated that there were two camelids found in the Juntura, *Megatylopus cf. gigas* and *Procamelus cf. grandis*. Preliminary work on postcranial material suggests that there were more than two genera. However, identification from postcrania proved inconclusive. This project examined the cranial and dental material found in the Juntura Formation. Nine mandibles representing eight individuals were examined for the study. The specimens are extremely weathered and were originally repaired with plaster. Specimens were identified through dental measurements and occlusal morphology. The size of second and third molars, presence/absence of the second premolar, and the morphology of the fourth premolar were key features used in identification. This work suggests that there are instead three genera of camels: *Megatylopus*, *Procamelus*, and *Aepycamelus*. While *Aepycamelus* is not a surprising find it is notable in our understanding of the ecology. Additionally, there are few identified sites of Clarendonian age in the Pacific Northwest. The specimens studied were identified as three juvenile individuals, two sub-adult, two adults, and one was an older individual with very worn teeth. This data gives us insight into the taphonomy of the locality and possible methods of site accumulation. Species level identification awaits a better understanding of Neogene camel evolution, especially those of the Pacific Northwest.

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

AIR SPACE BEYOND VERTEBRAE: PNEUMATICITY PATTERNS IN THE RIBS AND ILIUM OF A CRETACEOUS TITANOSAUR SAUROPOD

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Postcranial skeletal pneumaticity (PSP) is a widespread feature of sauropod dinosaurs that may have played a key role in weight reduction and the evolution of gigantism. PSP is most common in vertebrae, where it has received the greatest study. In titanosauriforms, however, PSP is also found in dorsal ribs and, occasionally, the appendicular girdles, primarily the ilium. To date, PSP in these regions has been little studied, and few quantitative measurements are available to compare with vertebral patterns. Here, we describe and quantify PSP for the dorsal ribs and ilium of a titanosaur from the Upper Cretaceous Black Peaks Formation of Big Bend National Park, Texas. The remains constitute a single individual (TMM 45891). Pneumaticity was observed and photographed along natural breaks during preparation. The air space proportion (ASP), the percentage of the total cross-sectional area occupied by air, was calculated from digital tracings of the broken surfaces.

The ilium exhibits camellate pneumaticity, with highly interconnected chambers from 1 to 10 cm across. The anteroventral and acetabular margins retain apneumatic trabecular (or spongy) bone. ASP varies from 78% dorsally to less than 50% in partly pneumatized regions. The rib heads are filled by camellate pneumaticity, with locally thin cortical bone. Distally, longitudinal camellae occupy more than half the length of the shaft, terminating within apneumatic trabecular bone surrounded by thick cortex. ASP is up to 80% in the rib head but less than 40% in all rib shaft sections. The highest values in the ilium and rib head are comparable to vertebral ASP for titanosaurs. Those in other regions were much lower, reflecting the co-occurrence of pneumaticity with apneumatic trabecular bone, which is scarce in titanosaur presacral vertebrae. These differences may reflect areas of greater biomechanical stress and should be considered when interpreting ASP for whole bones based on two-dimensional cross sections.

Technical Session 9: Mammals (Friday, November 4, 2022, 8:00 AM)

EVALUATING DIETARY DIVERSITY IN TRIBOSPHEMIC DENTITIONS: MACHINE LEARNING ANALYSES OF SIMPLE LINEAR MEASUREMENTS DISTINGUISH PRIMARY AND SECONDARY DIET TYPES IN EXTANT TAXA

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The evolution of the tribosphenic molar is considered a landmark event in mammalian history. As the foundation from which all therian dental specializations have evolved, the functional morphology of this ancestral dental system is essential to our understanding of the pattern and timing of mammalian evolution and ecological diversification. However, most paleobiological studies have assessed the form-function relationship in Mesozoic groups based on proxies from select, archetypal extant taxa (e.g., possums, tree shrews). Thus, the true breadth of dietary ecology and associated dental specializations in modern tribosphenic mammals remains unclear. Therefore, to better infer the dietary radiation of Mesozoic mammals, it is critical to establish a greater understanding of the dental functional morphology of modern tribosphenic mammals. Here we test a set of simple indices of dental functional morphology for use in dietary prediction. Nine linear measurements capturing key functional aspects of tooth shape (e.g., grinding basin area, length of shearing surfaces) were taken from the penultimate lower molar of 55 modern tribosphenic taxa. Primary and secondary dietary categories were assigned to each taxon. We used a combination of multivariate methods, including MANOVA, linear discriminant analysis (LDA), and principal component analysis (PCA), in concert with the machine learning technique of regression trees to assess which functional measurements might best serve as a proxy for diet. While primary diet was a partial predictor of tooth morphology, secondary diet was an important discriminator in both the regression tree and MANOVA, especially cristid obliqua and paracristid length, and hypoflexid width. The post-hoc analysis of our MANOVA returned a significant difference of means for 5/15 (33%) of our pairwise comparisons of dietary categories. Notably, our measurement scheme reliably distinguishes between “carnivore” and “insectivore with vertebrate supplement”, and “frugivore” and “insectivore with fruit supplement” dietary categories, with cristid obliqua and maximum molar length being the greatest factors. As the departure from strictly insectivorous ecologies is central to mammalian diversification during the Mesozoic, understanding the components that distinguish insectivory from other dietary categories is essential to interpretations of mammalian evolution and dietary radiation.

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Technical Session 6: Dinosaur Macroecology &
Macroevolution (Thursday, November 3, 2022, 1:45 PM)

TYRANNOSAUR FORELIMB REDUCTION IS NOT LINKED TO LARGE BODY SIZE

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The peculiarly short forelimbs of tyrannosaurid theropods, including the famous *Tyrannosaurus rex*, have generated considerable debate and speculation about their functions and the causes of forelimb reduction. Emphasis is often placed on the negative relationship between the length of the forelimb and body size in theropods, and this allometric pattern has been historically linked with the short arms of tyrannosaurids. However, little is known about forelimb scaling through ontogeny or evolution in large-bodied tyrannosaurids, and even less is known about how forelimb length evolved in the broader Tyrannosauroida, which includes small-bodied antecedents. Here, we evaluate forelimb scaling across Tyrannosauroida, using one of the largest fossil theropod datasets to date ($n = 279$; 50 tyrannosauroids), to assess the link between body size and forelimb length in this group. We used bivariate regressions of each of the forelimb bones and femur to evaluate ontogenetic allometry at the genus level and among progressively more inclusive tyrannosaurid clades. We find divergent trends between early-branching tyrannosauroids and tyrannosaurids, which, surprisingly, each exhibit isometric patterns at both evolutionary and ontogenetic scales. Whereas basal tyrannosauroids retain the plesiomorphic scaling of other non-avian theropods, the short arms of tyrannosaurids result from a change in intercept, rather than growth coefficient—in effect, the arm became significantly shorter at all body sizes. We further show, using ancestral state estimation, that this transition was likely to have occurred in the Early Cretaceous at small body sizes, during the myriad changes that established the tyrannosaurid bauplan. Among tyrannosaurid genera, negative forelimb allometry occurs only in the ulna of *Tarbosaurus* and the humerus of *Tyrannosaurus*, suggesting independent derivation of negative allometry in these two taxa. Nonetheless, these negative allometric trends cannot account for the short arms of these taxa, and instead represent variations on a theme established far earlier. Overall, these results refute the idea that short forelimbs in tyrannosaurids are linked to their large body sizes. Instead, our findings indicate that tyrannosaur forelimbs grew isometrically and were shortened at small body sizes in a restricted tyrannosaurid clade. This has ramifications for speculation on the causes and processes that led to forelimb shortening in tyrannosaurids.

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SINKING OUR TEETH IN: RECORDS OF CARNIVORAN MODIFICATION ON BONES OF SMALL PREY

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Carnivore modification on bones provide some of the only paleobiological proxies for predator- and scavenger-prey interactions. However, species interactions can be difficult to interpret from bone accumulations because not every predation event is recorded on prey bones. Furthermore, carnivore modification of smaller-bodied prey can be underrepresented because these relatively fragile bones are more likely to be entirely destroyed. To test the fidelity with which carnivore modification records known predator-prey dynamics for prey with easily modified bones, we evaluated carnivore modification on the bones of caribou (*Rangifer tarandus*) calves from the Arctic National Wildlife Refuge, AK. Calf bones were collected using standardized taphonomic surveys from 2010-2018. Each of the recovered calf bones (NISP = 435) was visually inspected for modification traces left by carnivores (mammalian and avian) and rodents. We then compared the frequencies of observed mammalian and avian bone modification (summarized by MNI and NISP) to observations (1983-2001) of carnivore activity on caribou calves within the Arctic Refuge. Available records indicate that the dominant predator of caribou calves was golden eagles (*Aquila chrysaetos*: 37% of calf mortalities annually), followed by brown bears (*Ursus arctos*) and wolves (*Canis lupus*), which were responsible for a combined 24% of mortalities. 39% of calf deaths were not predator related. We found that 18% of calf MNI recorded modification by avian predators, 35% by mammalian carnivores, and 55% were unmodified. Thus, avian modification is significantly underrepresented ($P < 0.01$). While 9% of calf MNI recorded both mammalian and raptor modification, co-occurrence was never observed on the same bone element. Discrepancies between observed calf predation and bone modification can be accounted for by differences in bone destructive by golden eagles relative to bears and wolves. The incongruence could also be attributed to high incidence of mammalian scavenging, as bite marks from active carnivory are difficult to distinguish from those produced by scavenging. Rodent modification is not present on any calf material, despite the high local abundances of microtine rodents. Carnivore modification of caribou calf bones are biased towards mammalian carnivores. Thus, paleobiological studies of prey seem unlikely to faithfully characterize predation patterns, particularly with respect to small and easily modified (neonatal) bones.

DIVERSITY AND DISTRIBUTION OF NEW PALEOGENE MAMMALIAN FAUNAS FROM THE TOPERNAWI LOCALITY (TURKANA DEPRESSION, KENYA)

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Princehouse, Patricia⁶

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Topernawi is a fossil-bearing area within the Ekitale Basin, located west of Lake Turkana in the Turkana Depression (Kenya). The Topernawi vertebrate fossils have been dated to between 29.5 ± 0.5 Ma and 29.3 ± 0.08 Ma, and more than 500 vertebrate specimens have been recovered from fifteen sites. The Topernawi Formation is bordered by $N40^{\circ}$ - 50° normal faults characterized by intrusive and cross-cutting dikes, with previous geological studies identifying five stratigraphic intervals (Units 1-5, oldest to youngest). Mammals are represented by the orders Hyracoidea (53% of all vertebrate fossils), Artiodactyla (Anthracotheriidae, 9.8%), Rodentia (Phiomorpha and Anomaluridae, 5.9%), Primates (Catarrhini, 5.9%), Hyaenodonta (2.4%), Embrithopoda (1.6%), Proboscidea (1%), Chiroptera (0.4%), Ptolemaiidea (0.2%), and Macroscelidea (0.2%). Fossils of Squamata (0.6%), Testidunes (0.2%), and Aves (0.2%) have also been recovered. Units 3 and 4 have yielded the largest number of fossil vertebrates, including a diversity of hyracoids, anthracotheriids, catarrhines, and rodents, whereas other units have yielded very few remains. Fossil sites from Units 3 and 4 can be combined into Northern (Unit 4), Central (Unit 4), and Southern (Unit 3) aggregates for faunal analysis. Hyracoids dominate each aggregate (44.7-63.8%) but are best represented in the South (63.8%), whereas primates are most common in the Central aggregate (9.5%). When calculating taxonomic evenness using abundances, we found that the North had the highest evenness values, whereas the South had the lowest. Smaller and rarer taxa are randomly distributed in space—macroscelids are only found in the North, ptolemaiids only in the Central aggregate, and chiropterans only in the South. The vertebrate fauna from the Topernawi Formation provides an important new data point for understanding the diversity and distribution of equatorial African mammals during the turbulent early Oligocene interval, and their

relationship to Cenozoic rifting episodes in the Turkana Depression.

Technical Session 1: Dinosaurs (Wednesday, November 2, 2022, 8:00 AM)

SKIN DEEP WITH *DIPLODOCUS*: IMPLICATIONS FOR THERMOREGULATION IN THE POROUS SCALES OF A YOUNG *DIPLODOCUS*

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The topic of dinosaur integument is an exciting and important component of our understanding of the physical appearance of dinosaurs. However, physical appearance is not the only discernible feature of integument fossils, because the physiology of such integument is another important aspect of these kinds of fossils. Osteoderms and feathers are among the most well studied in terms of physiology, with non-osteoderm bearing scales more recently being investigated towards their physiological purpose. In this study, fragments of ~3mm polygonal *Diplodocus* sp. scales were examined under a microscope and scanned using a micro CT scanner. Inside the scales, it was revealed that the skin possessed microscopic ligaments which branch down from the epidermis and connect to one another. These structures create a channel of holes underneath the epidermis, making the scales porous in nature. This sponge-like structuring dramatically increases the surface area inside the epidermis, which would potentially enable increased heat transfer through the skin. With this in mind, these scales could have utilized heat transfer in two different methods: evaporative cooling and natural convection. Considering these scales originate from what is hypothesized to be the ventral side of the animal, *Diplodocus* may have relied on wallowing in order to absorb water into its scales, which would then evaporate and cool the animal down. In terms of natural convection, the heat created by the body of the *Diplodocus* is transferred to the epidermal ligaments, heating the air within the channels of the skin. This heating would cause physical expansion and movement of the hot air out of the epidermis.

Technical Session 1: Dinosaurs (Wednesday, November 2, 2022, 8:00 AM)

RETRO-ACUPUNCTURE: CRANIOCERVICAL MUSCULATURE OF THE DICRAEOSAURID SAUROPOD DINOSAUR *BAJADASAURUS PRONUSPINAX*

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Among non-avian dinosaurs, craniocervical musculature, defined as the axial musculature attaching to the skull and responsible of positioning and moving the head, is poorly known. This is due in large part to the lack of intraspecimen association of cranial and cervical remains, and also to issues regarding homologies of these muscles among extant taxa. Previous studies on dinosaurs were mainly focused on theropods, such as *Tyrannosaurus* and *Allosaurus*, and ceratopsians. Among sauropods, only the craniocervical musculature of *Camarasaurus* and *Diplodocus* has been studied so far, showing similar configurations. In this contribution, a preliminary reconstruction of the craniocervical muscle groups in the dicraeosaurid *Bajadasaurus* is presented. Among the primary dorsiflexor muscles, the medial part of *transversospinalis capitis* is the medial-most muscle of this group, attaching to the sagittal crest laterally and invading the post-temporal fossa. The lateral part of *transversospinalis capitis* attaches along the caudal edge of the parietal wing. The medial portion of the *splenius capitis* inserts along the laterocaudal part of the sagittal crest, dorsal to the proatlantal facets. The lateral part of *splenius capitis* attaches along the dorsomedial surface of the paroccipital process, but does not invade the post-temporal fossa. Among the primary lateroflexor muscles, *longissimus capitis superficialis* is inferred to attach to the caudomedial surface of the distal portion of the paroccipital process, although leaving no osteological correlate. *Rectus capitis lateralis* attaches to the ventral and distal portions of the paroccipital process, leaving an L-shaped osteological correlate. Among the primary ventroflexor muscles, *rectus capitis ventralis* is the medial-most muscle of the group, attaching to the ventral surface of the basal tubera, leaving no clear osteological correlate. *Rectus capitis dorsalis* is inferred to attach to the caudomedial surface of the basal tubera, leaving no clear osteological correlate. The overall configuration of the craniocervical musculature in *Bajadasaurus* resembles that of other sauropods, excepting the absence of a fossa for *iliocostalis capitis* lateral to the foramen magnum in a depression, probably related to the atlanto-occipital capsule. This reconstruction represents the first inference in Dicraeosauridae, expanding the knowledge of the craniocervical musculature in flagellicaudatan sauropods.

Funding Sources Agencia Nacional de Promoción de la Investigación, el Desarrollo Tecnológico y la Innovación PICT 2018-00947 (to PAG)

Technical Session 6: Dinosaur Macroecology & Macroevolution (Thursday, November 3, 2022, 1:45 PM)

FUNCTIONAL INNOVATIONS DROVE EVOLUTIONARY RATES AND DIVERSIFICATION IN DINOSAURS

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Animals evolve to move through their habitats, and changes in the environment can drive functional adaptation. Typological comparative studies of extant and extinct species have clarified many of these adaptations but quantifying how functional systems evolve from ancestors to descendants has remained difficult to study due to an absence of methods that model such evolution. Here, we develop an evolutionary model for generalized functional equations and apply it to characterize hindlimb and forelimb retraction in dinosaurs. The parameters of these functional equations evolve at varying rates across the branches of a phylogeny and can detect directional shifts in function independent of evolutionary rate. These two types of changes—directional shifts and rate shifts—are inferred across the tree using a Bayesian reversible-jump Markov-chain Monte Carlo algorithm and are parametric extensions to models of microevolution. The model is also capable of producing phylogenies with branch lengths measured in functional change rather than time, allowing for a direct estimation of functional evolution along lineages, similar to branch lengths of molecular phylogenies representing genetic change. Additionally, the model can account for ancestral shifts in body size evolution and the uncertainty in limb posture. The analyses reveal that innovations in locomotor function gave way to shifts in the rate of evolution. For example, dinosaur lineages that evolved quadrupedality independently showed major reductions in the rate of locomotor evolution. This demonstrates that posture can strongly dictate the adaptability of locomotion. There was also accelerated evolution in the hindlimb mechanics of birds and bird-like (maniraptoran) dinosaurs. This was driven by a shift from a more reptilian style of locomotion where the leg muscles are anchored to the tail to a more bird-like style of locomotion where they are free to move independently. This shows how shifts in the style of locomotion can accelerate the evolution of functional systems. Dinosaur lineages with higher rates of locomotor evolution also had higher net speciation, linking bursts of locomotor evolution to diversification. The study provides a framework for studying functional evolution along lineages and demonstrates how innovations in function dictate further evolutionary change.

Funding Sources National Science Foundation (EAPSI-1714036); Dinosaur Research Institute; Donald L. Smith Memorial Scholarship (Earth Sciences, Montana State University).

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

REVEALING THE EVOLUTION AND DEVELOPMENT OF LIVING AND EXTINCT THEROPOD BEAKS THROUGH A UNIVERSAL MODEL OF GROWTH

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Vertebrate beaks, particularly bird beaks, show a remarkable diversity of forms due to developmental processes and natural selection. While studies have compared bird beak morphology to selective pressures such as foraging behaviour and diet, few have investigated how developmental processes influence beak shape. Our newly developed model, the power cascade, describes the growth and form of pointed structures (e.g., teeth, claws, and beaks). The power cascade is a log-log linear relationship that describes the expansion of the beak radius from the tip to the base. We measured beak shapes across 131 families of extant birds and non-avian theropods. Of the extant bird specimens, 93% followed the power cascade model ($r^2 > 0.95$). However, all non-avian theropod species followed the model ($r^2 > 0.98$). Plotting the power cascade slope and aspect ratio generates a morphospace that describes beak shape of all extant birds and non-avian theropods. Within this morphospace, we can explore how beak shape is grouped by phylogeny and ecological variables. From this we infer that the broad range of beak shapes in birds and non-avian theropods is determined by the power cascade patterning mechanism; natural selection acts on these shapes to evolve divergent vertebrate beaks shapes for many ecological functions.

Funding Sources Australian RTP, Monash Graduate Excellence Scholarship, Robert Blackwood Partnership, Australian Research Council - Grant Numbers: FT130100968, LP150100403, DP180101797

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

AN EXCEPTIONALLY WELL-PRESERVED HIGHER LANDBIRD FROM THE EARLY EOCENE LONDON CLAY

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The higher landbirds (Telluraves) consist of two clades, Australaves and Afroaves. Extant representatives of the basalmost lineages of both are raptorial species. Diurnal raptors were long thought to be monophyletic and classified among Falconiformes. However, all but falcons are now

understood instead to be among Afroaves in the superorder Accipitriformes. Falconiformes (falcons) are sister to Psittacopasseres (parrots and perching birds), among Australaves instead. A diversity of Early Eocene fossils from both Europe and North America have been interpreted as potential 'stem-parrots'. Despite the fact that all of their known skulls are crushed flat, it is clear that some exhibit raptor-like characters, such as large visor-like supraorbital prefrontal bones, not found in extant parrots. In contrast to the 'stem-parrots', the early Paleogene fossil record of both Falconiformes and Accipitriformes is all but non-existent. Fossil birds from the Early Ypresian London Clay Formation are remarkably three-dimensional and undeformed. We are studying one such specimen, including a complete skull and partial articulated skeleton, that is preserved in a dense pyritic/phosphatic nodule collected in Seasalter, Kent, England. From what is immediately visible, the skull most closely resembles those of extant Accipitridae. If it is, then it would significantly deepen the fossil record of reliably identified accipitrimorphs by tens of millions of years. However, given the raptor-like characters of some putative 'stem-parrots' and their relative abundance in the London Clay Formation, assigning the new fossil to either Australaves or Afroaves will depend on careful phylogenetic analysis. To this end, we generated microCT scans because the nodule is too hard and the three-dimensional articulated skeleton too delicate to be prepared mechanically. We are in the process of segmenting the individual bones and internal structures so they can be scored for phylogenetic analysis. The 3-dimensional preservation and recovery of internal structures, such as the semicircular canals, will enable the scoring of characters never-before available for putative 'stem-parrots'. Thus, the new fossil will be of significance regardless of whether it informs the anatomy of stem parrots or it extends the fossil record of Accipitriformes.

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

SURVEY OF METATARSAL PALEOPATHOLOGIES IN COELUROSAURIA FROM THE DINOSAUR PARK FORMATION

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By capturing moments in time in an animal's life, and recording evidence of strain, wear, and tear, paleopathologies provide a unique window into the lifestyles of extinct animals. While theropod pathologies are known, most of the literature are case studies and literature reviews. These can inform us on the range of pathologies possible, as well as possible behaviors, but few studies have investigated the frequency of pathology occurrence between or within particular taxa or

assemblages, and even fewer on a specific morphological feature. In the Dinosaur Park Formation, four taxa (Caenagnathidae, Ornithomimidae, Troodontidae, Tyrannosauridae) exhibit the arctometatarsalian morphology associated with increased gracility, which will be compared with a non-arctometatarsalian taxon: Dromaeosauridae. In an opportunistic survey of the collections of the Royal Tyrrell Museum of Paleontology (RTMP) and the University of Alberta Laboratory of Vertebrate Paleontology (UALVP), all metatarsals that could be identified and sided were scored for the presence of pathology/reactive growth, location, and simple descriptive category (proliferative, lytic or mixed). Preliminary descriptive statistics and two-way ANOVA tests were used to examine significant deviations from overall occurrences that define different groups and/or morphologies. Pathologies were observed in all groups, with tyrannosaurs having the highest occurrence rate followed by troodontids. When comparing the weight-bearing elements, all taxa except Caenagnathidae were most afflicted on metatarsal II and a variety of pathologies were observed, most frequently observed in and around the distal ligament pits suggesting an activity stress-related origin. This study is the first multi-taxa opportunistic survey of pathology occurrence of a specific hindlimb element within an ecosystem, and the first to investigate the relationship between the arctometatarsalian structure and pathology occurrence.

Funding Sources NSERC: Canadian Graduate Scholarships - Masters (CGS-M), AAPS: Charles H. Sternberg Scholarship, Dinosaur Research Institute: DRI Student Project

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

CRANIAL OSTEOLOGY OF A JUVENILE SPECIMEN OF *ACRATOCNUS YE* (MAMMALIA, XENARTHRA, FOLIVORA) AND ITS ONTOGENETIC AND PHYLOGENETIC IMPLICATIONS

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A juvenile specimen skull and mandible of the Antillean sloth *Acratocnus ye*, housed in the collections of the Florida Museum of Natural History, has been investigated in detail. The Holocene aged (~4,000 ybp) specimen was recovered from a cave in Macaya National Park, Haiti. Its excellent state of preservation and juvenile status allows observation of sutural connections among cranial bones, which normally fuse in adults of this taxon, and it preserves the ectotympanic and malleus, which are often lost in fossil sloths. Because of breaks in the skull, we are able to examine the internal anatomy of the bones surrounding the cranial cavity, and some of the cranial sinuses as well. The specimen reveals a number

of features not observed before in adult fossil sloths, including a parasphenoid element, a rostral tympanic process of the petrosal, a possible septal process of the maxilla, and vestigial lower tooth sockets, including one for the deciduous canine, and the first record of a deciduous incisor in Folivora. It also apparently possessed a paired mesethmoid element, only the second time such an element has been reported in Xenarthra. In addition, it preserves systematically significant features not present in adults of the same species, e.g., a groove for the tensor veli palatini muscle on the lateral surface of the pterygoid and large postpalatal foramina. It demonstrates other noteworthy ontogenetic changes in skull morphology that occur in Antillean sloths, e.g., in the shape of the occipital condyles. Lastly it preserves signs of its own cause of death, with the skull perforated by a large round hole likely made by a raptor claw. Study of this specimen highlights the need for further anatomical and phylogenetic investigations of Antillean sloths (Megalocnidae/ Megalonychidae), and for further ontogenetic studies of Folivora as a whole.

Funding Sources University of Tennessee at Chattanooga, Department of Biology, Geology, and Environmental Science, and Bramblett Gift fund

Education & Outreach Poster Session

HANDS-ON WITH 3D - BUILDING MORE THAN STATIC DISPLAYS WITH 3D PRINTING TECHNOLOGY

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People learn best when they make personal connections to the material they are learning. Teaching about past life on Earth is no exception, but traditional outreach and education methods can fall short of making meaningful links to deeper concepts. Fossils' fragility, weight, and rarity limits their use in many settings. Replicas bypass some of these obstacles, but are often expensive or lack enough detail to overcome the public's Uncanny Valley response around "real" fossils. Here we present two ways that 3D printing allowed us to avoid those limitations and provide learning opportunities unavailable with either original fossil specimens or casts.

One of the limits of mounted skeletons is their immobility. While weight and conservation are limiting factors in traditional mounts, outreach using 3D printed models can be freed from many of those constraints. The lightweight, replaceable nature of 3D prints mean they can be mounted in positions allowing movement, and movement-induced damage can be easily and quickly fixed. This allowed us to create an articulating model hindlimb of the ornithischian dinosaur *Oryctodromeus*. Visitors could manipulate the model to see its range-of-motion. We also designed the model to include metal hardware linked by rubber bands to simulate muscles. Visitors

were able to engage in hands-on muscle reconstruction. With the public taking an active role in mounting a dinosaur leg, they were better able to remember information about how muscles function in dinosaurs (as measured by visitor response surveys).

Another limit with fossils and casts is scale. Fine details or structures are unable to be easily interpreted as they are too small to be visible in public display. Upscaled (~20x) 3D prints of ostrich and Orinoco crocodile eggshell were used to demonstrate the variation in porosity between different archosaur nesting strategies. Water was poured into the models to simulate gas exchange. Many visitors were unaware that eggs have pores and our models allowed visitors to easily connect with them.

It is vital for educators to engage with the public in ways that provide authentic learning as technology changes, and not rely on outdated educational methods. 3D printed educational materials can avoid limits imposed by original fossil specimens and traditional casts by using movement, scaling, and durability. This leads to long-lasting educational gains compared to programs limited by their durability, rarity, or cost of the materials.

Technical Session 20: Crocodylomorpha (Saturday, November 5, 2022, 1:45 PM)

THE COMPLEX HISTORY OF EXTINCTION AND ORIGINATION SELECTIVITY IN CROCODYLOMORPHA

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Life history traits such as body size, habitat, and geographic range have been shown to affect the probabilities of species and genera going extinct and/or originating, although most of these predictors have muted or entirely absent effects during periods of mass extinctions. While some work has been conducted on how vertebrate extinction and origination is influenced by such traits during mass extinction events, little work has been done on how this compares to background selectivity. Crocodylomorpha, despite its depauperate modern diversity, has a long and diverse fossil record which includes species of varying sizes and habitats, making it a suitable clade for such an analysis. To accomplish this, I supplemented a previously compiled dataset of crocodylomorph body size and habitat data and timescaled the most recent supertree of 375 crocodylomorph species. Using this phylogeny and data, I then performed cluster analyses for each geological stage to test whether extinction and origination have been phylogenetically clustered at any point over the last 230 million years. I also performed stage-level logistic regressions to test whether extinction and origination have been influenced by body size and/or habitat. I find that extinction and origination are almost never clustered more than would be

expected by chance, although notable exceptions to this are clustered extinctions at the end of the Jurassic and Cretaceous periods. The majority of stages exhibit extinction selectivity against marine species, while most stages show no extinction selectivity for body size, although the end-Cretaceous has notable prolonged selectivity against small species. Finally, origination exhibits very little selectivity with regards to habitat or body size. Overall, these results demonstrate a complex history of extinction selectivity across crocodylomorphs which may be influenced by changes in their biotic and abiotic environments, while origination appears to have been nearly random. Beyond crocodylomorphs, these results indicate that investigations of longer time intervals may reveal variation in selectivity that may otherwise be missed when analyzing a mass extinction in isolation.

Technical Session 5: Amphibians & Early Reptiles (Thursday, November 3, 2022, 8:00 AM)

SLEUTHING THE SMALL: THE SECRETS OF SMALL-BODIED STEREOSPONDYLS FROM THE TRIASSIC OF ANTARCTICA AND THE INFLUENCE OF SIZE DISPARITY ON INFERENCE OF TEMNOSPONDYL PALEOBIOLOGY

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Temnospondyls were a diverse clade of non-amniotes with a cosmopolitan distribution throughout the Triassic. Their distribution makes them particularly useful in regional/global biostratigraphy. Recent fieldwork in the Fremouw Formation (Lower–Middle Triassic) of Antarctica recovered substantial amounts of temnospondyl material. We describe newly collected remains of small-bodied temnospondyls from the middle Fremouw Formation, a hitherto depauperate horizon whose biostratigraphic relations have remained elusive. Firstly, we identify material of the distinctive dissorophoid *Micropholis*, previously recorded from the lower Fremouw Formation, which provides evidence for a correlation of the middle Fremouw Formation with the upper *Lystrosaurus declivis* Assemblage Zone (and thus an Early Triassic age). Secondly, we identify remains of numerous small-bodied stereospondyls (< 5 cm skull length). Legitimately small-bodied taxa (e.g., amphibamiforms, lapillopsids, lydekkerinids, rhytidosteids, tupilakosaurids) are particularly common in Lower Triassic deposits, but small-bodied specimens could alternatively represent juveniles of taxa attaining much larger body sizes. Indeed, based on a suite of qualitative features (e.g., occipital profile, otic notch construction, ornamentation), we propose that these small specimens represent markedly immature capitosaurids, one such large-bodied clade (skull length often > 30 cm). However, when tested in a standard temnospondyl matrix in which OTUs vary in size by multiple orders of magnitude, our specimens cluster with small-bodied taxa like lapillopsids rather than with capitosaurids. We attribute this to a lack of

apomorphies and differential features that only appear in later ontogenetic stages in large-bodied taxa (e.g., long preorbital region, small orbits). When the OTUs are constructed based only on small-bodied specimens, whether as adults of diminutive taxa or as juveniles of large-bodied taxa, the Fremouw specimens instead cluster with juvenile capitosaurid OTUs. These findings underscore the importance of considering ontogenetic maturity and trajectory (e.g., metamorphosing versus paedomorphic) when making anatomical comparisons and phylogenetic assessments. Failure to account for these attributes, especially when incorporating small-bodied specimens, can lead to an ‘apples and oranges’ comparison in which anatomical differences are attributed strictly to phylogeny when ontogeny may be a substantial confound.

Funding Sources NSF PLR-1947094; NSF PLR-1341304

Technical Session 11: Synapsida (Friday, November 4, 2022, 8:00 AM)

NEW DATA ON THE ENDOCRANIAL ANATOMY OF THE LATE PERMIAN SCOTTISH DICYNODONT *GORDONIA* BASED ON COMPUTED TOMOGRAPHY

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The dicynodonts were abundant, globally widespread herbivorous synapsids of the Permian and Triassic periods. Although the external cranial anatomy of this group has been extensively studied, only recently has their endocranial anatomy received serious attention using CT-data, and the systematic scope of such work has been limited. Most of the dicynodonts previously studied using CT are among the smallest members of the clade (e.g. emydopoids, eumantelliids, pylaecephalids); larger dicynodonts (including the diverse and long-lasting subclade Bidentalia) have received comparatively little attention. Here, we work towards filling that gap by presenting a new CT-assisted reconstruction of the skull of *Gordonia traquairi*. *Gordonia* is a Late Permian dicynodontoid bidentalian taxon known from the Cutties Hillock and Hopeman Sandstone formations of Elgin, Scotland. It is a mid-sized dicynodont (skull length ~20cm) that has been known for over 100 years, but has received little study in terms of its anatomy and relationships. In large part this is because it is solely represented by moldic fossils contained within sandstone blocks, which have previously been studied mainly through destructive techniques. We applied μ -CT scanning to the most complete and best-preserved *Gordonia* skull, a relatively recently collected specimen nicknamed “The Elgin Marvel”, processing the

resulting data with Mimics to create digital 3D models of the cranium, mandible, and endocast. Phylogenetic analyses incorporating data gathered from the cranium and mandible further clarify the evolutionary position of *Gordonia* within Dicynodontoidea. Several aspects of the endocast differ strongly from previously studied small-bodied dicynodonts, notably the size and orientation of the pineal body. The pineal body of *Gordonia* is enlarged and strongly angled anterodorsally, unlike the columnar, dorsally-directed morphology of other studied dicynodonts, which is likely related to closure of the parietal portion of the intertemporal bar. The encephalization quotient (EQ) of *Gordonia* was calculated based on humeral-derived body mass estimates, yielding a range of values (0.24–0.28) within the established range for dicynodonts (0.18–0.52). Some features of this specimen (such as the morphology of the lateral dentary shelf) were found to vary with other specimens of *Gordonia*, though it is currently uncertain whether this represents individual variation or is of taxonomic significance.

Funding Sources Self-funded Palaeontology and Geobiology MScR

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

PALEOENVIRONMENTAL AND PALEOECOLOGIC RECONSTRUCTION OF THE CALF CREEK LOCALITY (CYPRESS HILLS FORMATION) IN SOUTHWESTERN SASKATCHEWAN, CANADA: RECONSTRUCTING CANADA'S MOST PROLIFIC PALEOGENE BONEBED

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The Eocene to Miocene Cypress Hills Formation (CHF) spans 28 Ma forming the conglomeratic caprock of the Cypress Hills plateau in southwestern Saskatchewan. The formation records one of the last significant sedimentation events in the western plains of North America at a time of major global climate fluctuations. The CHF contains the only high latitude, non-polar mammalian fossil assemblage known in Canada, spanning the Late Eocene to Early Miocene (Uintan to Hemingfordian land mammal ages). The Calf Creek Locality is Late Eocene in age (Chadronian 2) and was originally discovered in 1936 after bones were found eroding out of deposits along Calf Creek Coulee in the southeastern flanks of the Cypress Hills. This site is the most prolific Paleogene multitaxonomic bonebed in Canada, with numerous field campaigns resulting in the collection of roughly 60 fossil vertebrate families. This includes various creodonts and carnivores (ie. *Hyaenodon horridus*, *Hesperocyon gregarius*, and *Daphoenus* sp.), early horses and tapirs (*Mesohippus westoni*, *Mesohippus propinquus*, *Miohippus grandis*, *Colodon occidentalis*), small rhinos and deer (*Hyracodon priscidens*, *Leptomeryx* sp.), various “insectivores”,

brontotheres (*Megacerops coloradensis*, *M. kuwagatarninus*), and numerous freshwater fish, amphibians, and reptiles. This work presents a detailed sedimentologic and paleoecologic study to establish a depositional and environmental reconstruction for the Calf Creek Locality. Numerous studies of this kind are ongoing to establish a detailed regional framework to unravel the notorious complexity of the CHF.

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

A 3D PRINTING APPROACH TO MODELING MECHANICAL BEHAVIOR OF INDIVIDUAL VERTEBRAE FOR FUNCTIONAL ANALYSES OF FOSSIL SPECIMENS

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Bone functional morphology is partly defined by its mechanical properties, although most fossil specimen biomechanical analysis is limited to linear indices or digital simulations. Stiffness is a parameter of a biomaterial's microarchitecture and can be assessed through compressive mechanical testing. We used microcomputed tomography to examine the trabecular bone microarchitecture of the thoracic vertebrae in a domestic cat specimen. The compressive strength of five isolated vertebral bodies of the thoracic region was measured using a mechanical testing frame. The compressive test consisted of force-displacement testing to determine the Young's (elastic) modulus and strength of the individual bony thoracic specimens and 3D printed models. We hypothesized that the arrangement of 3D printed trabeculae architecture produces similar relative material properties to the bone, and 3D printed models can be sufficient for biomechanical analysis of the internal morphology of fossil vertebrae. Overall, the estimated modulus values were statistically similar between PLA models and bone, whereas the estimated yield strength values are statistically different between PLA models and bone. The estimated modulus values are not comparable between corresponding PLA and bone specimens for the same vertebral position, but estimated strength values may exhibit closer correspondence. This study aimed to propose a new approach for quantification of mechanical properties by comparing 3D printed “lattice-like” trabecular structures and actual cancellous trabecular bone. The analysis of the elastic modulus and yield strength of the PLA and bone demonstrates informative but general mechanical behavior using printed models to replicate biological specimens under compressive stress. The next steps will include the evaluation of printed PLA structures at different gradient infill densities to better match bone behavior. Although limited to a small sample size, these tests provide assessments of the viability of a physical modeling approach to understanding the functional morphological implications of vertebral body variation in the fossil record.

Funding Sources Department of Integrative Biology; 2021 Summer Research Grant; FAVE Lab (Jack Tseng)

Technical Session 18: Birds (Saturday, November 5, 2022, 1:45 PM)

USING THE CONSTRUCTIONAL FRAMEWORK TO ASSESS MACROEVOLUTION: THE CASE OF FOSSIL PENGUINS

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Penguins (Aves: Sphenisciformes) represent a clade of flightless birds that adapted to life in water. However, by being wing-propelled divers, penguins effectively transitioned from aerial to underwater flight, meaning that the morphology of their primary locomotory module (i.e., the forelimbs) underwent radical change.

Even though an extensive fossil record highlights the main steps through which this transition occurred, the precise tempo and mode of evolution are still to be determined in a quantitative sense. Moreover, understanding the macroevolutionary transition is a complex task because it requires accounting for many variables that interplay. To overcome the challenge, the idea that inspired this project is the constructional morphology framework ideated from Adolph Seilacher. In Seilacher's view, features of organisms in an evolutionary context can be explained as three main "forces": phylogenetic, structural and adaptational constraints.

To adopt this view with a modern approach the analysis started from a Fossilized Birth Death phylogenetic inference of the penguin clade with an updated matrix to assess the phylogenetic constraints. The evolutionary tree suggested that stem penguins may have radiated as fewer large clades rather than the previously established "pectinated" tree, with the famous Oligocene giant penguins forming a large monophyletic group of taxa rather than a paraphyletic assemblage.

The posterior distribution of trees was then used to generate a set of ancestral state estimates for the humerus and the tarsometatarsus to assess whether the rates of evolution of these two bones differed due to different evolutionary pressures in action. With the ancestral shapes estimated using this method it was possible to generate a morphospace that is also informed on the time axis, and thus is possible to assess the rates of evolution as morphological distances over time.

Evolutionary rates were different in different parts of the body. Whereas the humerus changed the most during the earlier stages of penguin evolution, the tarsometatarsus changed the most during later stages. This pattern may suggest that morphological evolution of the wing may have been under stronger evolutionary pressures perhaps due to its locomotory

role. Far from being outdated, the Seilacher framework can still be a valuable approach to assess macroevolution, meaning that old ideas supported by novel methodological approaches may still guide future research.

Funding Sources Massey University Doctoral Scholarship

Technical Session 19: Marine Mammals (Saturday, November 5, 2022, 1:45 PM)

CORRELATIONS BETWEEN CRANIAL AND INNER EAR MORPHOLOGIES OF ODONTOCETES

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The odontocete skull shows features that indicate specialized behaviors implemented during the animal's life such as echolocation and feeding preference. Echolocation is a highly specialized adaptation for feeding and navigation that involves the production of high frequency sound and the reception of its echo. Previous studies show that measurements of bony labyrinths of the inner ear show interspecific differences in hearing frequency ranges of odontocetes. We can use CT scanning technology to take detailed measurements of these features. Features of the inner ear that correlate with high frequency hearing include a low basal ratio, greater inter-turn distance, and lower number of turns of the cochlea. Cranial features such as asymmetry and telescoping may be involved in high frequency sound production. Odontocetes use echolocation to assist in a variety of methods to capture prey such as suction and raptorial feeding. These feeding strategies may be determined by cranial morphological features such as longirostry (long rostrum) and brevirostry (short rostrum). Finding adaptive and functional relationships between these features is an important part of understanding the evolution of odontocetes and how they behave today. To determine if there are any evolutionary correlations between cranial features for feeding, sound production, and sound reception, I collected existing measurement data of inner ear and cranial features ("characters") from a total of 65 extinct and extant odontocete species. These data incorporate all the major extinct and extant odontocete families. I mapped the characters onto phylogenetic trees. Phylogenetic generalized least squares statistical analysis was used on the phylogenetic trees to assess correlations between characters. The results provide evidence that cranial asymmetry is correlated with echolocation. There is no evidence that cranial telescoping is correlated with echolocation. The findings in this study also indicate that brevirostrine odontocetes emit higher frequencies than longirostrine odontocetes. Lastly, this study finds a positive correlation between most inner ear features, except for comparisons involving number of cochlear turns and basal ratio. This reflects how size dimensions of the cochlea are directly proportional to one another. This work highlights and clarifies relationships among cranial features for echolocation and feeding within odontocetes.

Technical Session 19: Marine Mammals (Saturday, November 5, 2022, 1:45 PM)

OSTEOHISTOLOGY OF *PHIOMICETUS ANUBIS* REVEALS UNIQUE LIFE HISTORY PATTERNS IN EARLY CETACEANS

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Protocetids are stem cetaceans that document a suite of evolutionary transformations of whales from terrestrial ancestry to obligate aquatic life. Despite the importance of protocetids in understanding the major ecological transition of cetaceans, very little is known about their life histories. Osteohistology of early whales could provide an exceptional opportunity to study their biology and has the potential to reveal new insights into their life histories. Here, we examine the bone and dental histology of *Phiomicetus anubis*, an early protocetid whale from the Middle Eocene (Lutetian) of the Fayum Depression of Egypt. The specimens sampled are the right lower third incisor and the right lower first molar teeth, the sixth thoracic vertebral centrum, the sixth left rib, and a shaft of a midthoracic right rib of *Phiomicetus*. The ribs show increasing bone mass and do not have an open medullary cavity, whereas the thoracic vertebral centrum is mostly spongy. This suggests that *Phiomicetus* could be a shallow water suspended swimmer. Using histology-based skeletochronology, *Phiomicetus* was likely over 21 years old at death based on the number of recorded Lines of Arrested Growth (LAGs). The presence of External Fundamental System (EFS) in ribs sections, enamel with many incremental lines, and filled pulp cavity, with no ability to distinguish many bands in the dentin, are indicative of an adult senescent individual. Skeletochronology suggests that *Phiomicetus* reached sexual maturity between 4-5 years of growth and skeletal maturity at 11 of age. The thoracic vertebral centrum is largely characterized by well-vascularized, fibrolamellar bone, suggesting rapid growth early in life. Moreover, the ribs are extensively remodeled but have slowly deposited lamellar-zonal bone and poorly organized parallel-fibered tissue in the

outer cortex, with medially directed shaft growth throughout ontogeny. These findings would contribute to uncovering patterns of the life history and deciphering ontogenetic and evolutionary trends in the early whale evolution.

Symposium: International Community Connections (Wednesday, November 2, 2022, 1:45 PM)

TEACHING WRITING SKILLS IN ONLINE AND IN-PERSON PALEONTOLOGY AND EVOLUTION COURSES

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Foundational knowledge and technical skills are typically emphasized in biology curricula, but transferrable skills, including reading comprehension, narrative writing, and expository writing, are under-prioritized, to the detriment of biology graduates and to the scientific field. In an effort to target this gap, we designed assessments in online paleontology and evolution courses to foster these skills among students. We offer model writing assignments for a variety of college course levels. Appropriate analysis and comparison of major texts like the *Origin of Species* can be approached by students in general-education courses as well as upper-level science students within their major. Students in general-education and upper level biology courses were asked to read individual chapters of *Origin*, and record one new insight from it (e.g., a clarifying passage, an idea we know is wrong, or a question that is still unanswered). Once they identified their insight, students were asked to research that idea in recent (last 5 years) primary literature and share it with the class in a wiki page on the course LMS. In a mid-level historical geology/biology course, we developed an assignment asking students to pick a fossiliferous geologic formation from a curated list, research the primary literature about several details of that formation (e.g. age, lithology, location, species, paleoclimate, etc.), and present their findings in a written paper and oral presentation. Many students chose formations near their homes. The most challenging aspect of this assignment for the students is finding a modern-day analogue of the depositional environment represented in their chosen formation, but by doing this, biologists can be introduced to paleoecological interpretation, and make connections with their own life experiences. These assignments allow novice students in paleontology to develop their written/oral communication skills alongside critical thinking skills with a variety of low to high stakes assessments and can be applied in online or in-person learning environments.

DENTINE OXYGEN ISOTOPES REVEAL PERIODIC FRESHWATER INCURSIONS IN MARINE REPTILES FROM THE WESTERN INTERIOR SEAWAY OF MANITOBA, CANADA

Gold, Virginia¹, Fayek, Mostafa¹, Brink, Kirstin²

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Mosasurs were the dominant marine reptiles of the Late Cretaceous Western Interior Seaway (WIS) of North America. Previous oxygen isotopic work on mosasaur enamel in specimens collected from Alabama and Kansas suggests that mosasurs (like modern sea snakes) migrated weekly to bi-weekly from saltwater to freshwater, potentially for osmoregulation, based on $\delta^{18}\text{O}$ patterns. The timing of these freshwater incursions was calculated using incremental growth markers in the dentine, termed von Ebner lines (VEL), which were visible through the enamel on the external surface of the teeth. Normal VEL has consistent width, colour, and regularity in mosasaur teeth. However, some teeth when examined in cross-section demonstrate abnormal VEL (darker colour, thicker in width and irregular in the pattern). In this study, we sought to determine if 1) a similar pattern of freshwater incursions could be observed in $\delta^{18}\text{O}$ values of the dentine within mosasurs originating from Manitoba, and 2) if the abnormal VEL could be correlated to the freshwater incursions, suggesting a relationship between migratory stress and dentine development. To achieve our goal, we measured the oxygen isotopic composition of dentine along transects of sectioned teeth, using the in situ analytical capabilities of Secondary Ion Mass Spectrometry (SIMS). To minimize the potential effects of diagenesis, as is typical in dentine, the specimens were mapped using Electron Probe Microanalysis (EPMA) and Scanning Electron Microscopy (SEM) to identify areas of dentine devoid of the visible tubule and crack infilling with rimming. Results produced via SIMS suggest a migratory pattern similar to that recovered previously from enamel can be recovered from the dentine based on $\delta^{18}\text{O}$ value shifts. The average values obtained from the Manitoban mosasurs are like those of the Kansas specimens, at $\sim 17.1\text{‰}$ and $\sim 17.4\text{‰}$ respectively, which is likely due to the animals living in similar open marine and/or nearshore environments in the central WIS. Analysis of the patterns of $\delta^{18}\text{O}$ depletion shows no correlation with the formation of abnormal VEL, suggesting migration to freshwater environments does not cause enough stress on the animal to affect dentine mineralization. Future work will determine if the formation of abnormal VEL is due to other biological processes affecting tooth development or if they are the result of the fossilization process.

Funding Sources Funding is provided by an NSERC Discovery Grant to Dr. Kirstin S. Brink.

Colbert Prize Session

A QUANTITATIVE ANALYSIS OF ALVEOLAR SPACING IN AN ONTOGENETIC SERIES OF MYSTRIOSUCHINE PARASUCHIDS AND IMPLICATIONS FOR THE EVOLUTION OF DENTAL COMPLEXITY IN PHYTOSAURIA

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Investigating the variability of morphological characteristics holds key insights to assessing the paleobiology of extinct organisms. Variation in rostral morphology (e.g. shape) and dental characteristics (e.g. length of alveolar spaces) has been observed in Archosauria, especially in longirostrine taxa, and can be attributed to ontogenetic, phylogenetic, or functional changes in dental complexity where rostral elongation may influence the spacing or number of alveoli. For example, alveolar spacing in some archosaurs may increase in mesiodistal length between alveoli (e.g. theropods and distal teeth of extant crocodylians) or remain the same through growth (e.g. mesial teeth of extant crocodylians) suggesting developmental, phylogenetic, and functional differences in alveolar spacing. Qualitative analyses of phytosaur (large semi-aquatic archosauriforms) tooth-bearing elements show wider mesiodistal alveolar spacing in some small specimens (rostral width < 2cm) than in large specimens (rostral width > 2cm); however, whether alveolar spacing in phytosaurs is an ontogenetic, phylogenetic, or functional character remains unclear. To quantitatively assess the effect of ontogeny and rostral morphology on alveolus spacing in Phytosauria, we developed and tested four linear models using mesiodistal alveolus spacing, rostral width (=transverse width at the premaxilla-maxilla suture), and robusticity (=narrow and lacking a crest, or wide and possessing a crest and ventral bulge) measurements from nearly complete skulls of *Redondasaurus bermani* (~200-900 mm), *R. gregorii* (~800 mm), *Machaeroprotopus pristinus* (~1220 mm), and *M. mccauleyi* (~1150 mm) and inferred ontogenetic stages (skeletally mature or immature). The best predictive model using Akaike information criteria (AIC) indicates a significant relationship (AICwt=1) between alveolus spacing and the interactive effect of ontogenetic stage, rostral width, and robusticity. Rostral shape significantly influences alveolus spacing ($p < 0.01$) and plays a larger role in alveolar spacing than ontogeny, indicating more dental complexity related to phylogenetic or functional drivers. In our sample, phytosaur alveolar spacing decreases through ontogeny and is significantly affected by rostral shape, suggesting a link between the formation and elongation of rostra and alveolar characteristics that may elucidate the evolution of dental complexity in longirostrine archosaurs.

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

A NEW DWARF ONYCHODONTID FISH FROM THE LATE DEVONIAN OF THE CANADIAN ARCTIC

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Here we report on an undescribed species of Onychodontiformes in the genus *Onychodus* from the Late Devonian Nordstrand Point Formation of Devon Island's Grinnell Peninsula, Nunavut, Canada. Onychodontiformes are a grade of poorly known stem-actinistian sarcopterygian fishes distinguished by poorly ossified and highly kinetic skulls and parasymphysial tooth whorls. This new form is represented by tooth whorls, partial lower jaws, and a potential premaxilla. The combination of microstructural ribs in the parasymphysial tusks and the dentary flange on the lingual side of the dentary support the referral of this new species to the genus *Onychodus*. Preliminary phylogenetic analysis of the new taxon also supports the referral of this form to the genus *Onychodus*. The NUFV onychodontid is distinguished from other Onychodontiformes by raised longitudinal enamel ridges along the parasymphysial tusks, uniform or near uniform length teeth across the length of the dentary, a weakly expanded dentary flange on the lingual surface, and diminutive size. Using scanning electron microscopy earlier work assessed the ontogenetic stage of these specimens. The herringbone pattern of the microstructural ribs meets along the central line of the parasymphysial tusks, suggesting these 12 cm long fishes were adults at the time of death rather than juveniles. This new taxon is interpreted as a small-bodied predator and a prey item for larger vertebrates as evidenced by the presence of its teeth in coprolites. Additionally, this new form expands our understanding of the Late Devonian community of the Canadian Arctic, representing the first record of an onychodontid from the Okse Bay Group and one of the latest occurrences of the group in time.

Funding Sources Department of Biodiversity Earth and Environmental Sciences at Drexel University

Technical Session 3: Marine Reptiles (Wednesday, November 2, 2022, 8:00 AM)

VALIDATING OSTEOLOGICAL CORRELATES OF INTERDIGITAL WEBBING AND FLIPPER FORM IN EXTINCT AQUATIC AMNIOTES.

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There is, at present, no reliable way to infer the presence of soft-tissue paddles in extinct aquatic tetrapods. Most living aquatic amniotes have webbed hands and feet, with shapes and extents that bear on their functional ecology. In exceptional cases, the soft tissue of fossil paddles may be preserved, but otherwise, we can only guess at its presence, and our guesses remain dubious. Previous studies have suggested various osteological correlates for webbing, such as a relatively symmetrical finger region, splayed palm bones, distinctly shaped proximal-most and ungual phalanges, and a lengthened anterior-most finger. However, none of these suggested osteological correlates have been tested for association with webbing across living amniotes. Thus, we lack a validated method for identifying webbed limbs in the fossil record. This calls into question previous inferences about the presence of webbing in several species of extinct aquatic amniotes, and limits our ability to reconstruct their locomotor biomechanics. Herein, we present data evaluating these correlates across a phylogenetic bracket that includes all extinct crown amniotes. We also demonstrate that several morphometric indices can be used to reliably infer the presence of and compare flippers among mammals and reptiles. These indices have the potential to enhance our understanding of locomotor trends in secondarily aquatic tetrapods.

Funding Sources NSF GRFP Grant No. DGE 1752134, YIBS Doctoral Pilot Grant, YIBS Doctoral Dissertation Improvement Grant

Technical Session 1: Dinosaurs (Wednesday, November 2, 2022, 8:00 AM)

AN ASSESSMENT OF THE SAUROPOD DINOSAUR FOSSILS COLLECTED FROM THE CRETACEOUS DINOSAUR BEDS OF MALAWI DURING THE 1930 F.W.H. MIGEOD EXPEDITION

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In 1930, a Natural History Museum, London expedition led by F.W.H. Migeod collected fossils from the Cretaceous Dinosaur Beds of Malawi. The expedition prospected the Mwaka Syunguti area in northeastern Malawi where expeditions led by F. Dixey explored just years prior and L. Jacobs in the 1980–90s revisited. In his 1931 report, Migeod published an inventory of the fossils collected from four localities that included multiple sauropod dinosaur individuals, one of the most common fossils recovered from the Dinosaur Beds. Unlike the fossils from the Dixey and Jacobs expeditions, which include the holotypes and referred specimens of titanosaurian sauropods *Malawisaurus dixeyi* and *Karongasaurus gittelmani*, those collected by Migeod await scientific study. Therefore, uncertainty remains on how these specimens relate to the known fossils from Malawi and other Cretaceous African deposits like the neighboring Galula

Formation in Tanzania. Upon study, it is apparent that Migeod misidentified some bones in his report, but the fossils are mostly well-preserved and informative. NHMUK R8630 is an associated titanosaurian sauropod with anterior caudal vertebrae, scapula, and pubis that compare favorably with SAM 7405 holotype of *Malawisaurus dixeyi*, a titanosaurian with a history of taxonomic revision and uncertainty surrounding referred specimens that may represent a potential chimera with *Karongasaurus*. NHMUK R8630 also resembles *Mnyamawamtuka moyowamkia* from the Galula Formation of Tanzania, albeit with a slenderer femur and a more developed lateral trochanter of the fibula. NHMUK R8628 is a significantly larger individual than NHMUK R8630 with similar caudal vertebrae but differs in pubis morphology and a slenderer fibula. NHMUK R8627 is a heavily weathered sauropod specimen represented by appendicular and vertebral elements and differs from both NHMUK R8630 and R8628 with non-procoelous anterior caudal vertebrae. Finally, NHMUK R8631 is an indeterminate theropod that includes a coracoid, pubis, and several fragmentary appendicular elements, contrasting with its initial identification as a sauropod. In sum, these specimens support the presence of at least two different sauropods in the Dinosaur Beds of Malawi and may be fruitful in resolving ongoing referral issues regarding the specimen assemblage of *Malawisaurus* and *Karongasaurus*. Furthermore, NHMUK R8631 represents a significant addition to the otherwise near-absent theropod record of the Dinosaur Beds of Malawi.

Technical Session 9: Mammals (Friday, November 4, 2022, 8:00 AM)

ATTENUATED EVOLUTION OF MAMMALS THROUGH THE CENOZOIC

Goswami, Anjali¹, Noirault, Eve¹, Coombs, Ellen², Clavel, Julien³, Fabre, Anne-Claire⁴, Halliday, Thomas⁵, Curtis, Abigail⁶, Watanabe, Akinobu⁷, Beatty, Brian⁷, Geisler, Jonathan⁷, Simmons, Nancy⁸, Fox, David L.⁹, Churchill, Morgan M.¹⁰, Felice, Ryan N.¹¹

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Placental mammals make up 94% of extant mammalian diversity, with ~6144 recognized extant species and an immense variation in ecology and morphology. Despite a

wealth of data from extant and fossil species, the nature of the placental mammal radiation has remained a contentious topic, with significant uncertainty in the timing of the initial divergence driving continued debate on the tempo, mode, and drivers of placental evolution. Contributing to the uncertainty is the exclusion of fossils from most studies, despite the initial early Cenozoic radiation overwhelmingly involving wholly extinct lineages. Here we present the first quantitative analysis of skull morphological evolution spanning the full breadth of living and extinct placental diversity, with 757 3-D landmarks and sliding semi-landmarks for 322 species representing every extant family and most extinct orders. We conduct these analyses across 1800 evolutionary trees, with divergence estimates binned into sets spanning 5-million year intervals from 100 to 70 million years ago, to constrain the impact of phylogenetic uncertainty on our results.

Placental cranial variation is highly concentrated, with only whales and rodents occupying distinct regions. Rates of cranial evolution peak early in placental radiation and generally decline through the Cenozoic. Whales, armadillos, and extinct “ungulate” orders consistently display rapid evolution, while stem placentals, evolve much more slowly than the crown group. Rodents and bats display moderate to low evolutionary pace, suggesting a dissociation of taxonomic and morphological diversification. Social, precocial, aquatic, and herbivorous species evolve fastest among placentals. Finally, ancestral shape estimates for three of the four extant superorders are highly similar, suggesting that the earliest representatives of the placental radiation may continue to elude unambiguous identification.

Funding Sources ERC grant STG-2014-637171, NSF EAR 1349607, Gerstner Scholar Postdoctoral Research Fellowship, NERC training grant NE/L002485/1, NSF EAR 1338262

Virtual Posters

A PLIOCENE BOXFISH FROM NEW ZEALAND -- A PREVIEW OF FUTURE ENVIRONMENTAL CHANGE?

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We report on an articulated fossil boxfish (Ostraciidae, Tetraodontiformes) recently recovered from the Pliocene of the North Island of New Zealand. The specimen (catalogued at the Museum of New Zealand TePapa Tongarewa as NMNZ S.46695) is preserved in a concretion collected from the Tangahoe Mudstone Formation, a mid-Pliocene (3.0-3.4 Ma) shallow marine deposit, at Waihi Beach, South Taranaki (the same formation has also produced the first Southern Hemisphere record of a monachine seal). The fossil boxfish measures 10.7 cm in standard length, with an estimated total length of ~13 cm (the caudal fin rays are not preserved). The

specimen has a body length:depth ratio of ca. 2:1, and exhibits the rectangular boxy appearance characteristic of the group. The fish is preserved in right lateral view, lying on its side, and has an intact body covering of fused plates, formed of mineralized hydroxyapatite, that rigidly encase the fish. The plates are hexagonal to subhexagonal in shape and somewhat rounded in places, and largest close to the dorsal midline. The larger plates have a conical raised area in the center of the plate. The specimen also preserves other features consistent with its identification as a boxfish, including a thickened keel-like brow and 'horn' above the eye, an extended snout, and a narrow caudal peduncle that projects straight back from the posterior edge of the body. Fossil boxfish have previously been recorded from Northern Hemisphere sites ranging in age from Cretaceous to Quaternary, but not from the Southern Hemisphere. Recent reports note that the Yellow Boxfish (*Ostracion cubicum*) and several other tropical Pacific fish species are now being seen by divers off of northern New Zealand – the Pliocene boxfish from Taranaki, as well as an intriguing addition to New Zealand's paleohistory, may also reflect how the ongoing impact of climate change will return New Zealand to a 'warm world' marine ecosystem in the future.

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

3D CRANIAL IMAGING IS THE SWAN SONG FOR THE CASSOWARY CASQUE AS A VOCAL RESONATOR

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Many avian groups rely on vocalizations to communicate, and these sounds can vary dramatically in frequency and amplitude. Modern cassowaries (*Casuarius* spp.) are capable of producing booming, low-frequency (32 Hz) calls with near-infrasonic components. These deep sounds may be particularly important in attracting mates, deterring rivals, and protecting territories at a distance because cassowaries are generally solitary in their rainforest habitats and sexes only have extended interactions during the breeding season. How the near-infrasonic components of these vocalizations are produced by cassowaries is not understood; nonetheless, the cranial casque has been an anatomical feature popularly hypothesized to mechanically assist in sound resonance. This, in turn, has led cassowary casques to be used as modern analogs in paleontological studies for potential sound-assisting structures in non-avian dinosaurs (e.g., headgear of oviraptorosaurs and lambeosaurine hadrosaurs) despite a lack of empirical evidence that supports this claim in cassowaries. Based on gross dissection of adult specimens, the nasal cavity does not appear to invade the casque, a mechanical

requirement for resonance (i.e., enhancement or intensification of sound via air-filled cavities as a vibrating column of air passes exteriorly). However, the process of dissection itself may obscure the potential relationship between the casque compartment and the nasal cavity if such passageways are minute and few. Here, we assess for the first time the 3D internal casque space and nasal sinuses of southern cassowaries (*C. casuarius*; n = 18) over postnatal ontogeny using non-destructive μ CT imaging to evaluate the validity of casque-mediated vocalizations. We determined no life stage at which the internal casque space and nasal sinuses of *C. casuarius* possess patency large enough to satisfy the criteria for the casque acting as a resonator (≥ 2.0 mm in diameter). Therefore, we identify no anatomical means for the casque to function in resonance. This contrasts with lambeosaurine hadrosaurs (e.g., *Parasaurolophus*), which possessed patent connections between the nasal cavity and internal crest, enabling derived vocalization. Although the casques of cassowaries may lend themselves to understanding other aspects of archosaur ornament evolution, they do not appear to be an appropriate model for vocal resonance and may better represent the headgear of non-lambeosaurine dinosaurs.

Funding Sources National Science Foundation, Western Interior Paleontological Society, American Association for Anatomy, and The Company of Biologists.

Colbert Prize Session

A MINUTE CHONDRICHTHYAN MECKEL'S CARTILAGE FROM THE HANGENBERG BLACK SHALE IN MOROCCO AND ITS POSITION IN CHONDRICHTHYAN JAW MORPHOSPACE

Greif, Merle¹, Ferron, Humberto², Coates, Michael I.³, Klug, Christian¹

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Chondrichthyan remains are often known from their teeth or fin spines only, while their cartilaginous endoskeletons require exceptional preservational conditions to become fossilized. During the Famennian (Late Devonian), the taphonomic conditions were suitable repeatedly to preserve cartilage and even complete skeletons of chondrichthyans in the Maïder and Tafilalt regions of Morocco. While most skeletal remains of Famennian chondrichthyans were found in older layers of the eastern Anti-Atlas, such remains were unknown from the Hangenberg black shale and only a few acanthodian teeth had been found in these layers previously. A new Meckel's cartilage from the Hangenberg black shale in Morocco was found and described. Since it is not directly associated with teeth or other skeletal elements, elliptical Fourier and Principal Component Analysis were applied in order to morphologically

compare it to 41 other chondrichthyan taxa to find its possible affiliation. In the PCA and in a cluster analysis, it plots closest to some acanthodian jaws and particularly next to an ischnacanthiform jaw. The presence of ischnacanthiform teeth in the same strata make an ischnacanthiform origin likely. Additionally, the presence of a polygonal structure in the new Meckel's cartilage supports this suggestion. This polygonal structure suggests the presence of tessellated calcified cartilage which is a synapomorphy of modern and extinct crown chondrichthyans but similar structures are also known from certain acanthodians, one of them being *Ischnacanthus sp.*

Funding Sources We greatly appreciate the financial support of the Swiss National Science Foundation (project nr. 200020_184894).

Romer Prize Session (Thursday, November 3, 2022, 8:00 AM)

HOW DO PTEROSAURS LAUNCH?: MODELLING MUSCLE MOMENTS IN AN ORNITHOCHEIRAEAN MODEL

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Unassisted launch is a vital and challenging part of powered flight which constrains the size of modern birds. Pterosaurs are known to have reached sizes far larger than modern birds without any indicators of loss of flight. Three different hypothesised launch motions have been proposed as explanations for how pterosaurs circumvented size constraints: bipedal burst launching, bipedal counter-motion launching, and quadrupedal launching, however the force generation of these launch motions remained unclear. A 5m wingspan ornithocheiraeon musculoskeletal model was created featuring 34 key muscles in the wings and hindlimbs to test the moment generating capacity of these different launch motions. Using soft tissue constrained range of motion and inverse kinematics, launch motions were created for each hypothesis. The moment arms for each modelled muscle were calculated as the model was run through each of the hypothesized launch motions. The modelling showed that, at the point of launch, the summed moment arms in the flexion/extension plane for the burst launch reached 0.139m for each hindlimb, the counter-motion launch reach 0.032m for each hindlimb, and the quadrupedal launch reached 0.757m for each forelimb. Moment generating capacity of each launch was determined using the product of the moment arm and the maximum isometric force. An estimate of the maximum isometric force was calculated by scaling the averaged maximum isometric force of closely related extant species under a variety of assumptions including different pterosaur model mass estimations, different muscle proportions derived from the extant phylogenetic bracket, as well as isometric and allometric scaling factors. The modelling determined that, for an averaged muscle proportion in the flexion/extension plane at the point of launch, the bipedal

counter-motion launch can generate moment of 18.223nm in each hindlimb, the bipedal burst launch motion can generate a moment of 11.126nm in each hindlimb, and the quadrupedal launch motion can generate a moment of 162.427nm in each forelimb. While different modelling assumptions have a substantial effect on the magnitude of the moments in each tested scenario, the quadrupedal launch invariably produced the largest moment generating capacity at the point of launch. This indicates that the launch motion most capable of producing the required moment to circumvent the size limit seen in modern flying animals is the quadrupedal launch.

Funding Sources: University of Bristol Bob Savage Memorial Fund
Geological Society of London Alan and Charlotte Welch Fund

Technical Session 6: Dinosaur Macroecology & Macroevolution (Thursday, November 3, 2022, 1:45 PM)

FEMORAL ONTOGENY OF THE TRIASSIC SAURISCHIAN *TAWA HALLAE* SUGGESTS THAT NEOTHEROPOD HINDLIMBS EVOLVED VIA SHIFTS IN ONTOGENETIC TIMING

Griffin, Christopher¹, Pezzoni, Neil G.², Pintore, Romain³, Irmis, Randall B.⁴, Smith, Nathan D.⁵, Turner, Alan⁶, Marsh, Adam⁷, Nesbitt, Sterling J.²

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Early dinosaurs and their kin have been suggested to possess high anatomical and histological variation throughout ontogeny. Because of this, conspecific individuals at similar body sizes may possess disparate ontogenetic ages and character states—this problem is often further exacerbated by low sample sizes and stratigraphic separation, and can muddle basic taxonomy and the often controversial hypotheses of early dinosaur phylogeny. The Late Triassic dinosaur *Tawa hallae* is a key taxon in reconstructing dinosaurian relationships, being recovered as either an early theropod (with herrerasaurids as theropods) or a herrerasaur (with herrerasaurids as non-theropods), and often allied with *Chindesaurus bryansmalli*. Here, we integrate geometric morphometrics, quantitative character state analysis, and histology to study ontogeny in a stratigraphically constrained sample of *Tawa hallae* femora (n = 36) from the Hayden Quarry (HQ), Ghost Ranch, New Mexico. Non-metric multidimensional scaling (NMDS) recovered a continuous ontogenetic series spanning from more immature individuals to mature individuals with *Chindesaurus*-like features. Ontogenetic sequence analysis confirmed high variation in the

sample, with multiple reconstructed ontogenetic sequences that were consistent with the ontogenetic signal recovered in NMDS. Femoral histology of three specimens confirmed that these character state transitions correlate with ontogeny, with one large femur possessing signs of asymptotic growth (i.e., an external fundamental system). 3D geometric morphometric analysis (25 landmarks, 638 semilandmarks) indicated ontogenetic signal when performed only on the HQ assemblage. The addition of *Herrerasaurus*, *Chindesaurus*, neotheropods, and *Eodromaeus* to the analysis strongly suggested that the HQ *Chindesaurus*-like morphs are conspecific with *Tawa hallae*. *Tawa* femora are anatomical intermediates between herrerasaurids and neotheropods, with immature *Tawa* femora possessing neotheropod-like features before transitioning into herrerasaur- and *Chindesaurus*-like anatomy at more mature ontogenetic stages. This is evidence that *Chindesaurus/Tawa* and herrerasaurids are non-neotheropod theropods, with the former representing a transition from the more plesiomorphic herrerasaurid anatomy to the derived neotheropod condition. Because neotheropod anatomy is present in immature *Tawa* femora, this suggests that portions of the neotheropod postcrania evolved via shifts in ontogenetic timing.

Funding Sources CTG—NSF Postdoctoral Research Fellowship in Biology

Colbert Prize Session

THE LONG AND SHORT OF IT: DYNAMIC WAYS IN WHICH SMALL-MAMMALS RESPOND *IN-SITU* TO ENVIRONMENTAL GRADIENTS IN TIME AND SPACE

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In the face of ecological change, change of some kind is imperative for species who wish to remain in place. The nature and degree of this change is of great interest, as it sheds light into a species adaptive potential as well as the ways in which they may continue to respond to future change, brought on by increased anthropogenic activity. We set out to uncover the ways in which species respond *in-situ* to environmental change using geometric morphometrics and stable isotope analysis for a suite of 10 small-mammals, across the Holocene in the Great Basin, USA. Geometric morphometrics provides a quantitative way to assess size and shape dynamics, while Stable Isotope Analysis records a snapshot of species' resource usage, that can be used to estimate dietary niche size and placement. Together, these two metrics arm us with a way to measure species' long-term evolutionary change, as well as their short-term behavioral flexibility. The relationship between these axes of variation and their degree of coupling is unknown.

We found that species, are responding individualistically

across space and time both morphologically and isotopically. Even the same species at different localities often responds to selective pressures in unique ways. Additionally, we found that counter to our predictions, species' response spatially did consistently reflect those seen through time. We observed that across space and time, that both dietary flexibility and morphological variation can change quickly, over decadal to centennial time-scales or possibly even quicker, and are both important in buffering species to ecological change. Lastly, we found that a space for time substitutions is not as black and white as we would have hoped, and the relationship between morphological variation and dietary flexibility seen today is not the same as the one across the Holocene. Counter to our prediction of fossil species exhibiting more morphological and isotopic variation due to larger time averaging intervals, and thus more room for variation to occur, we consistently see species today exhibit greater levels of variation than those of the past. Specifically modern species exhibit greater levels of isotopic variation, suggesting that Modern species are especially susceptible to anthropogenic induced change and are more likely to respond via dietary change than morphological change.

Funding Sources ZoRF, Oregon State University Zoological Research Fund., Graduate Teaching Assistantship, Oregon State University

Virtual Posters

SEARCHING FOR THE PERMO-TRIASSIC BOUNDARY IN KWAZULU-NATAL PROVINCE, SOUTH AFRICA

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Palaeontological research has been undertaken in middle-to-late Permian deposits of the South African Main Karoo Basin since the middle 19th Century. Despite this, most of the palaeontological and stratigraphic research has been carried out in the southern parts of the basin, where the stratigraphic succession is thicker and outcrops are better exposed. The northern sector of the Main Karoo Basin has been relatively neglected - especially with regards to tetrapod biostratigraphy. This is particularly true of the KwaZulu-Natal midlands, where localities in the Stoffelton and Bergville districts have yielded numerous tetrapod fossils but have been overlooked in recent biostratigraphic revisions. Indeed, many of the collected specimens from this part of the basin are unprepared and/or have limited provenance data associated with them. Here we present the preliminary results of our recent palaeontological and sedimentological studies in the Balfour Formation in KwaZulu-Natal Province, supplemented by palaeontological data from Karoo fossil collections. Historically productive and newly identified localities were visited, enabling us to provide a better stratigraphic context for historically collected

specimens. Fossils representing at least 18 tetrapod taxa have been recovered and we confirm that both the latest Permian *Lystrosauros maccaigi-Moschorhinus* Subzone of the *Daptocephalus* Assemblage Zone and the Early Triassic *Lystrosauros declivis* Assemblage Zone are present in surface outcrops. Elsewhere in the basin, the boundary between these two assemblage zones represents the Permo-Triassic Boundary and is considered to fully preserve the effects of the End-Permian Mass Extinction that occurred ca. 251.9 Ma ago; although further work is needed to determine how complete the boundary succession is in this part of the basin.

Funding Sources The NRF and its African Origins Platform, GENUS (DST-NRF Centre of Excellence in Palaeosciences), and the Palaeontological Scientific Trust (PAST) are acknowledged.

Technical Session 11: Synapsida (Friday, November 4, 2022, 8:00 AM)

SURVIVAL OF THE NOVEL: DERIVED FAUNIVORES ARE THE FORERUNNERS OF MAJOR SYNAPSID RADIATIONS

Grossnickle, David¹, Hellert, Spencer², Kammerer, Christian³, Angielczyk, Kenneth D.⁴, Lloyd, Graeme⁵

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Evolutionary radiations generate most of Earth's biodiversity, but are there common ecomorphological traits among the progenitors of radiations? In Synapsida (mammalian total group), 'small-bodied faunivore' has been hypothesized as the ancestral state of most major radiating clades. To quantitatively test this hypothesis across multiple radiations, we used a meta-phylogeny ('metatree') of Carboniferous through Eocene (305–34 Ma) species in conjunction with jaw lengths (as a proxy for body size) and diet reconstructions for 404 synapsid species. We focus primarily on five major radiations: (i) non-therapsid pelycosaurs, (ii) non-cynodont therapsids, (iii) non-mammaliaform cynodonts, (iv) non-therian mammaliaforms, and (v) therians. Contrary to our expectations, we did not find universal support for the hypothesis that 'small-bodied faunivore' is the ancestral state of radiating synapsid groups. Although faunivory was the typical ancestral diet of each major ecological radiation, the radiation forerunners were not relatively small-bodied in many non-mammaliaform synapsid groups. Instead, the small-to-large trend in body-size within radiations does not become common until the end-Triassic size bottleneck near the base of Mammaliaformes. We also find that ecomorphological diversification was often preceded by the extinction of contemporary clades. As a potential causal mechanism for the observed macroevolutionary patterns, it is tempting to assume

that the forerunners of major radiations were relatively unspecialized faunivores with reduced extinction risk. However, 'survival of the unspecialized' does not fully explain our results. Many of the progenitors of major synapsid radiations may appear to be unspecialized faunivores, but this is likely due to observational bias: the early lineages of each radiation were 'unspecialized' relative to many of their later descendant lineages, but, compared to their contemporaries, they exhibit numerous novel characters. These characters were likely important in promoting their long-term survival and diversification, but it appears that mass extinctions and other faunal turnovers were necessary for the lineages that possessed these characters to reach their full evolutionary potential. Therefore, 'survival of the novel' appears to be a persistent macroevolutionary pattern throughout synapsid history.

Funding Sources NSF DEB-1754502, NSF DBI-1812126

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

PRESERVED FEMORAL EPIPHYSES IN THE IGUANODONTIAN DINOSAUR *TENONTOSAURUS TILLETI*

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Cartilaginous epiphyses are a well-recognized part of archosaur anatomy, providing joint cushioning between hard bone surfaces. While both birds and crocodiles have hyaline cartilage epiphyses, these taxa do not share the same depth and distribution of epiphyseal cartilage, making it impossible to predict with accuracy the morphology of cartilaginous epiphyses within Dinosauria. Preserved cartilaginous epiphyses are almost unknown within Dinosauria. A femur from a juvenile specimen of the iguanodontian *Tenontosaurus tilletti* (Early Cretaceous Cloverly Formation, Montana) has complete, well-preserved epiphyseal caps on both its proximal and distal ends. The surfaces of the preserved epiphyses contain small, evenly spaced indentations which are likely the lacunae of chondrocytes. CT scans of the femur reveal that the shape of the epiphyseal surface differs significantly from that of the underlying bone, demonstrating that the morphology of the bony joint is not a perfect indicator of the shape of the original joint.

Technical Session 2: Paleoecology (Wednesday, November 2, 2022, 8:00 AM)

PLAYING (AERODYNAMIC) SLOTS: EVOLUTION OF THE AVIAN WINGTIP WITH IMPLICATIONS FOR ECOLOGICAL INFERENCES FROM WING SHAPE IN AVIAN AND NON-AVIAN THEROPODS

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Vane width and barb angle asymmetries in the primary feathers have been proposed as indicators of flight capacity in fossil taxa. These conclusions have been primarily based on observations of lower average ratios of asymmetry in living flightless birds, as compared to volant taxa. However, recent comparative studies have found statistically significant overlap in both vane width asymmetry and vane barb angle asymmetry between secondarily flightless and volant birds. Based on numerical models, existing experimental data, and foundational theory, I propose that vane asymmetries in primary feathers primarily provide aeroelastic stability of separated feathers at the wingtip (wingtip slots).

Aeroelastically stable, separated primaries have two primary effects: 1) improved low-speed flight performance through stall reduction and an improved upstroke; and 2) increased aerodynamic wing aspect ratio. Birds using tip slots have aerodynamic aspect ratios that greatly exceed their anatomical aspect ratios, flying as though their wings were longer and narrower than they are anatomically. Separated primary feather stability only occurs at feather vane width ratios greater than 3:1. Feathers with anatomical vane asymmetry ratios less than 3:1 are aerodynamically symmetric. I built a large comparative dataset of wing shape and primary feather shape variables from spread wings. Analysis of this database showed a strong correlation (Pearson Product Moment > 0.8 , $p < 0.05$) between degree of tip slotting and the presence of high vane asymmetry. Species with asymmetry ratios in the upper quartile all have slotted wingtips, and no avian species found to have slotted wingtips lacked a vane width asymmetry ratio greater than 3:1. Based on the vane width and barb angle asymmetries in fossil taxa, the capacity to separate the primary feathers into a slotted wingtip likely evolved crownward of *Confuciusornis*. This does not indicate that more stem-ward taxa lacked powered flight. Instead, slot-related flight specializations seen among living taxa appeared comparatively late in avian evolution. Wing aspect ratios of early birds and microraptorines cannot be directly compared to those of living birds. Fossil taxa and living taxa that possess contrasting wing shapes may have had more similar ecologies than previously appreciated. For example, the aerodynamic wing aspect ratios of *Microraptor* and living, short-winged forest hawks with slotted wingtips appear to be quite similar.

Technical Session 10: Soft Tissues & Taphonomy (Friday, November 4, 2022, 8:00 AM)

A STUDY OF *ORODROMEUS* TAPHONOMY AT EGG MOUNTAIN, PART OF THE UPPER CRETACEOUS TWO MEDICINE FORMATION NEAR CHOTEAU, MONTANA.

Hannebaum, Zakaria J., Varricchio, David

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Orodromeus makelai was a small thescelosaurid dinosaur known from the Upper Cretaceous Two Medicine Formation (TMF) of Montana, and notably from the Egg Mountain (EM) quarry. Most dinosaur fossils at EM consist of preserved eggs and clutches mostly of the troodontid *Troodon formosus*, whereas *Orodromeus* is represented entirely by skeletal material. This study seeks to determine the unique taphonomic factors driving the preservation of *Orodromeus* material at EM by exploring three hypotheses: (1) *Orodromeus* was fossorial, like the closely related *Oryctodromeus cubicularis*, and burrowing facilitates its preservation; (2) the abundance of fossils reflects an *Orodromeus* breeding ground, and (3) *Orodromeus* remains represent individuals preyed upon and gathered by *Troodon*.

New *Orodromeus* fossils collected from EM between 2010 and 2016 have helped shed light on the taphonomic processes affecting *Orodromeus* and potentially give insights into their parental care. A survey of these specimens and ones held at the Museum of the Rockies showed a lack of signs of predation, weathering, and abrasions indicating *Orodromeus* remains underwent rapid burial postmortem with little transport. This is like *Oryctodromeus* remains from the older Cretaceous Blackleaf and Wayan Formations of, respectively, southwest Montana and Idaho. Preparation of a plaster field jacket designated “Jacket A”, taken from EM in 2016, has revealed an articulated juvenile *Orodromeus* skeleton preserved in relative life position with a noticeable 90 degree kink in its neck reminiscent of other fossorial animals found preserved in burrows.

Analysis of the *Orodromeus* death assemblages at EM and the TMF focused on attrition rates by examining femur length. This revealed EM lacked perinate, young juvenile, and adult aged animals with attrition beginning at 6 cm while increasing steadily until peaking at 11 cm, before dropping off. A similar trend is observable in the TMF with attrition peaking at 11 cm, however, the TMF assemblage includes specimens representing all ontogenetic stages with the data more representative of a bell curve.

Preservation bias potentially explains the lack of specimens on either end of this ontogenetic spectrum, however, in the context of our observations, perhaps peak attrition correlates with the age *Orodromeus* became independent of direct parental care. This could indicate *Orodromeus* exhibited an extended period of parental care of 2-3 years based on existing histological data.

Funding Sources The National Science Foundation grant (EAR) nos. 0847777 and 1325674, the Montana State University Undergraduate Scholars Program

Technical Session 2: Paleoecology (Wednesday, November 2, 2022, 8:00 AM)

DIETARY PALEOECOLOGY OF UNGULATES IN RELATION TO ENVIRONMENTAL CHANGE IN THE MIOCENE DOVE SPRING FORMATION, CALIFORNIA

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The Miocene of western North America is associated with tectonic processes that significantly altered topography and climatic gradients. Such landscape changes, along with global cooling, contributed to the contraction of forest habitats and the expansion of novel open-canopy habitats throughout North America. Mammals responded by evolving feeding ecologies that exploited new vegetation resources, forming communities without modern analogues. We analyzed the dietary ecology of ungulate mammals from the Dove Spring Formation, which spans 12.5 to 8.5 Ma, located in the Mojave region of southern California. We used a well-resolved chronology and stable isotopes of carbon and oxygen to investigate paleoecological changes in three families (Antilocapridae, Camelidae, and Equidae) over half-million-year time intervals.

We sampled enamel of 158 cheek teeth from the common ungulate families. Carbon isotopes of herbivore enamel track the photosynthetic pathway of plants consumed, with a range of depleted $\delta^{13}\text{C}$ values suggesting consumption of C3 plants and a range of wooded to open environments throughout the basin. With high-resolution stratigraphy and geochronology, we investigated correlations to environmental change linked to local tectonic history. The $\delta^{13}\text{C}$ values of the Dove Spring ungulates range from -27.0‰ to -5.7‰ , becoming more depleted over time. Statistically significant changes in diet occurred at 10.0 Ma, 9.5 Ma, and 8.5 Ma. At about 10 Ma, an interval of basin rotation and westward translation along the Garlock fault coincides with reduced variation in $\delta^{13}\text{C}$. Basin extension beginning around 9.0 Ma was coeval with an increase in $\delta^{13}\text{C}$ variation near the top of the formation. Individual families show similar trends, although the timing of change in their diets differs. Antilocapridae and Camelidae exhibit dietary change at 10.5 Ma and 9.5 Ma, respectively, while Equidae exhibits significant changes at 9.5 Ma and four additional 0.5-Myr intervals.

Our ^{18}O results show no significant changes over time, suggesting no major changes in precipitation regime. We also analyzed paleosol carbonates as an independent estimate of vegetation; $\delta^{13}\text{C}_{\text{SOIL}}$ and $\delta^{18}\text{O}_{\text{SOIL}}$ values ranged from -5.1‰ to -2.5‰ , becoming more depleted over time, paralleling the trends in enamel values. The long-term trends in both enamel and soil carbonate $\delta^{13}\text{C}$ values may indicate an increase in canopy cover related to drainage changes triggered by uplift in the southern Sierra Nevada.

Funding Sources Geological Society of America, The Paleontological Society, University of Michigan Earth and Environmental Sciences Department, University of Michigan Rackham Graduate School

Romer Prize Session (Thursday, November 3, 2022, 8:00 AM)

MINERAL METABOLISM AND THE ORIGIN OF CELLULAR BONE

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Bone is a living regenerative tissue capable of growth, adaptation, and healing. These functions are a major driver in the evolution of vertebrates and make the vertebrate skeleton unique and more dynamic in its physiology than that of invertebrates. Many of the functions ascribed to bone tissue are due to the internalized cellular system known as the lacunocanalicular network (LCN), which houses entrapped osteocytes and their many cellular processes. The LCN is a highly interconnected network whose connectivity is only rivaled by the neuronal network. Studies attribute various physiological roles to osteocytes, including bone remodeling, mechano-sensation, and mineral metabolism. Given these critical physiological roles, it is intriguing that the earliest bone to appear in vertebrate evolution is the anosteocytic (lacking osteocytes) bone of jawless heterostracans. Nothing is known of the evolutionary conditions that led to the origin of osteocytes in jawless osteostracans or the initial functions of osteocytes. In fossil bone osteocytes do not preserve, but the LCN preserves with remarkable fidelity, making lacunae reliable proxies. Studying the earliest osteocyte lacunae has been hampered by methodological limitations that preclude resolution of the LCN's complex 3D nature or that have been unable to achieve cell-process-level resolution in fossil material. To produce high-resolution 3D images of the earliest osteocytes, I apply focused ion beam-scanning electron microscopy (FIB-SEM) tomography in concert with machine learning for cell detection and segmentation to image the first jawless vertebrates with osteocytes, the osteostracans. This novel application resolves areas of low density around osteocyte lacunae and their canaliculi in osteostracan bone. This is evidence for demineralization that would have occurred in vivo as part of osteocytic osteolysis, a known mechanism of mineral homeostasis and one of the key roles of osteocytes in extant vertebrates. Heterostracans' anosteocytic bone, was inherently unable to metabolize its mineral composition as efficiently as their co-occurring osteostracans. Therefore, the novel evidence for mineral metabolism in osteostracans strongly supports the hypothesis that a physiological demand for mineral metabolism was the principal driver in the initial evolution of osteocytic bone in osteostracans and potentially facilitated their success and the subsequent retention of osteocytic bone in vertebrates.

Funding Sources Deutsche Forschungsgemeinschaft (DFG, WI 3144/4-1).

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

NEW CROCODYLIFORM MATERIAL FROM THE CLOVERLY FORMATION (ALBIAN) OF WYOMING, USA

Harper, Aren Q.¹, Turner, Alan², D'Emic, Michael D.¹

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Terrestrial ecosystems suffered a continent-wide extinction in North America in the mid-Cretaceous (Aptian to Cenomanian), roughly coincident with the flooding of the continent by the Western Interior Seaway, the forging of a biogeographic connection with Beringia, and the rapid spread of angiosperms. Dinosaurs living at that time in North America had broad geographic ranges, suggesting little difference in environment across the continent. However, Cretaceous crocodyliforms display high levels of morphological and ecological disparity, suggesting that they might display stronger faunal provinciality. Relative to most clades, mid-Cretaceous North American crocodyliforms are poorly understood. There are 12 named crocodyliform species from seven mid-Cretaceous North American formations, with several unnamed taxa as well. Three of these species pertain to Goniopholididae, a clade of predominately broad-snouted semi-aquatic animals. Mid-Cretaceous goniopholidid material has been reported from at least five formations across North America, suggesting that goniopholidids, although widespread, remain poorly understood. We report newly excavated material, including associated cranial, axial, appendicular, and dermal elements of at least four individuals found in two quarries in the Cloverly Formation. This material was found in association with several dinosaur taxa in bonebeds. Phylogenetic analysis recovers the new material in Goniopholididae. The largest individual is similar in size to the largest previously excavated crocodyliform individuals from the Cloverly Formation, with an estimated body mass of about 100 kg. This new associated material will help determine whether mid-Cretaceous crocodyliforms display more biogeographic heterogeneity than the dinosaurs they coexisted with, perhaps due to smaller geographic ranges owing to their smaller body size and specialized ecological niches.

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

INTERNAL PETROSAL ANATOMY OF TWO EARLY MIOCENE LILOPTERNS

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Here we show comparisons of the internal petrosal anatomy of two Early Miocene protheroitheriid liopterns, *Tetramerorhinus* and the generally more derived *Thoatherium*. Using μ CT segmentations of the inner ear bony labyrinth and petrosal venous sinuses, we present several virtual endocasts describing the extent of these structures relative to surficial features of the petrosal bone.

These reconstructions show that *Thoatherium* differs from *Tetramerorhinus* in having a thinner cochlea but with a much longer expression of the secondary lamina along the abneural wall of the cochlear canal. The dorsal vestibule of *Thoatherium* also shows a well-defined prominence for the common attachment of the anterior and lateral semicircular ampullae.

Both lioptern taxa show the development of a substantial network of petrosal venous sinuses, with those in *Thoatherium* being relatively more expansive. In both taxa, the major confluence of this venous network with intracranial dural sinuses begins as an excavated region of the petrosal bone posterior to, and parallel with, the common crus and endolymphatic canal. This excavation then arcs dorsally over the anterior semicircular canal. A second excavation also appears anterior to the common attachment of the anterior and lateral ampullae. Finally, and only in *Thoatherium*, there is a third excavation (continuous with the first) arching dorsolaterally over the posterior semicircular canal and extending deeply into the mastoid region.

These reconstructions are the first depictions of an internal petrosal sinus structure in liopterns. It is premature to make definite statements on the polarity of the internal petrosal characters mentioned above, but it appears likely that *Thoatherium* represents a more derived condition in the anatomy of its inner ear and surrounding structures.

Technical Session - New Methods (Thursday, November 3, 2022, 10:15 AM)

METHODS OF BODY MASS ESTIMATION IN TEMNOSPONDYL AMPHIBIANS

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Body mass is strongly associated with physiology, ecology, and locomotory style in extant taxa, making it a key proxy for inferring the biology of extinct species. A variety of extinct animals have been subject to studies of body mass estimation, including dinosaurs and mammals, but comparatively less attention has been paid to other tetrapods. Temnospondyls, a group of amphibious tetrapods from the Carboniferous–Mesozoic, have not been included in most studies of body mass estimation. This is largely because there are no direct descendants of temnospondyls to serve as a direct modern analogue, and temnospondyl fossils are often incompletely preserved. Body mass estimation methods like graphic double integration (GDI) and minimum convex hulling (MCH) require complete or near-complete skeletons, while extant-based linear scaling models require consistent preservation of a size-dependent metric (e.g., stylopodial circumference [HcFc]). These challenges mean that many current body mass estimation methods are nearly impossible to apply across the range of known temnospondyl fossils. For instance, Permian taxa are often laterally or dorsoventrally flattened, and articulated skeletons are rare.

Two exceptions to these preservational issues are *Eryops megacephalus* from the Permian of North America and *Paracyclotossaurus davidi* from the Triassic of Australia, known from complete, 3-dimensionally preserved skeletons. Accordingly, we apply a wide range of established body mass estimation methods to these animals. Methods include 19 general or amphibian-specific models derived from skeletal measurements and two volumetric reconstruction methods: GDI and MCH.

To evaluate the accuracy of these methods, the masses of five extant analogues were estimated with the same methods: the giant salamanders *Andrias japonicus* and *Andrias davidianus*, *Ambystoma tigrinum* (tiger salamander), *Taricha torosa* (California newt), and *Crocodylus porosus* (saltwater crocodile). We find that MCH, head width, HcFc, and total length methods can provide accurate mass estimations across this range of living taxa, suggesting their suitability for estimating the body masses of temnospondyls. Based on these results, we propose that *Eryops* weighed between 102 and 222 kg, and *Paracyclotossaurus* between 159 and 365 kg. We propose that our work will provide a basis for accurately estimating the body mass of temnospondyls and present an opportunity to analyse evolutionary patterns in body mass over time.

Funding Sources Australian Government Research Training Program to LJH and Australian Research Council Discovery Early Career Research Grant (DE190101423) to NEC

Technical Session 15: Theropods (Saturday, November 5, 2022, 8:00 AM)

3D HISTOLOGY ON THE GROWTH, REMODELING, AND BIOMECHANICAL LOCOMOTOR LOADING IN JUVENILE TYRANNOSAURS COMPARED TO MODERN RATITES

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Growth patterns and osteohistology of extant taxa are commonly compared to that of extinct vertebrates to interpret growth and ontogenetic maturation in extinct clades. This is traditionally done via ground thin sections, but recently microCT scans have been utilized as these newer processes are non-destructive. Synchrotron phase contrast microCT improves edge definition and resolution with larger samples. Although not as detailed at the tissue and cellular level, these 3D scans allow for better interpretation and modeling of complicated vasculature.

We applied synchrotron scanning at the Canadian Light Source BM13 beamline to metatarsals and femora of juvenile tyrannosaurids from sub-yearling to teenage stages, and hindlimb elements of ratites for extant grounding of interpretations.

The 3D imaging revealed abundant oblique canals, a vasculature type often mistakenly interpreted in 2D thin section histology and thus underrepresented. These canals can sometimes be indistinguishable from longitudinal canals in 2D but are readily apparent in 3D. They represent fast growth and or increased nutrient transport to tendon and ligament attachments. Because of their connective tissue relationships, they are frequently observed with Sharpey's fibers and thus have a biomechanical relationship. In the juvenile tyrannosaurids, oblique canals correspond with inferred direction of locomotor ligament tension. Cortical canal densities correlate inversely with maturity in both the ratites and tyrannosaurids.

3D vascular structure otherwise confirmed interpretations of predominant canal direction and remodeling zones identified from ground thin sections. Results demonstrate synergy between planar but higher-resolving 2D histology and extensive volumetric sampling possible with synchrotron microCT.

Funding Sources Canadian Light Source, Oklahoma State University

Education & Outreach Poster Session

ESTABLISHING A STATE FOSSIL FOR MINNESOTA (USA)

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State symbols can be powerful educational tools. Students typically learn about their state bird, state flower and other symbols throughout their education, becoming aware of how they fit into their local ecosystems. Just six U.S. states do not have a designated state fossil, including Minnesota. We at the Science Museum of Minnesota (SMM) aimed to change this through a voting campaign to raise awareness of Minnesota's fossil record. Initially, eight fossil candidates were proposed that represented different parts of the state, of geologic time, and different kinds of ancient life. These ranged from stromatolites to ancient *Bison*. A brief open session was held prior to the vote, allowing members of the public to add other fossils to the ballot. Only one candidate emerged from this phase, *Castoroides*, the Giant Beaver. These nine candidates were put to a vote, managed through the museum's website in August and September, 2021. Most voting was done by individuals or families, but a separate educator page was created so that teachers could enter the individual votes of their students. A running tally was kept throughout, which included gathering zip codes from voters.

Alongside voting, educators from SMM developed an interactive virtual lesson that outlined the state fossil initiative, delved into each candidate, and explained the democratic process of voting. This importantly helped raise awareness of not only Minnesota's fossil record, but also a key lesson in civics, including multiple activities. The lesson is freely available online to anyone.

Large efforts were made to get the word out about the initiative and the lesson. Despite pandemic limitations, we engaged in schools and community events, presented on local television, and advocated through social media and other virtual platforms. In total, SMM gathered nearly 11,500 votes for the Minnesota State Fossil. Minnesotans were highly engaged with the content and we received numerous passionate messages for different candidates. A clear front-runner emerged early on and maintained that lead all the way to the end of voting, which was the Giant Beaver.

This public campaign helped raise awareness of the fossil record in a way that simply choosing one candidate could never do. Through this process, we also have key data for the Minnesota legislature, as the project moves to establish the Giant Beaver as the official State Fossil of Minnesota.

Funding Sources This project is largely thanks to the dedicated staff and resources of the Science Museum of Minnesota.

Education & Outreach Poster Session

WILD, WONDERFUL, AND UNINFECTED: LESSONS LEARNED RUNNING IN-PERSON STEM DAY CAMPS DURING A GLOBAL PANDEMIC IN URBAN AND RURAL WEST VIRGINIA

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Informal education is a vital supplement to school-based K-12 STEM education, and to close gaps left by remote learning or time out of school due to illness. However, in low-income areas, e.g., much of West Virginia, barriers to entry are significant hurdles for student access. Even with parental desire the demand for extracurricular programs is often unmet, especially for older students who don't need supervision or may have already joined the workforce. More barriers include cost, food insecurity, and transportation. While survey data demonstrates parental understanding of these programs' benefits and an eagerness to enroll their children, there is often 1 spot available in such a program for every 3 students who would enroll, meaning 2/3 of interested students remain underserved. Due to the additional challenges from the COVID-19 pandemic, the situation is getting worse, not better. Further, low broadband availability (in WV, <85% of homes have access to broadband, ranking it 45th in the nation) means programming cannot easily be moved online, and our anecdotal experience suggests that students are ready to reengage in person. Since the pandemic began, proficiency in math (28%) and science (27%) in WV are at their lowest levels since data collection began in 2014, ranking WV 45th in the nation for K-12 education. However, 2½ weeks of STEM extracurricular activities per year equates to roughly a full additional year of instruction per student by the time they graduate, and students in better served areas may be getting as much as 2–3x that enrichment. In 2021, West Virginia Science Adventures partnered with the National Youth Science Foundation to reduce participation costs for their summer day camps and extend existing camps to new counties. We learned that by reducing fees, providing free lunches, and in some cases transportation, that we were able to engage with a more economically and racially diverse group of campers while maintaining safety by following CDC best practices for summer camps. Parents were grateful and interest has been high enough that camps were expanded in both scope and location for summer 2022. Demand remains greater in more urbanized parts of the state, but population density and ease of travel likely play a role and progress is being made in rural areas as well. By working together to focus on reducing or eliminating barriers to entry, we can hope to start closing the achievement gap for rural and low-income students. **Funding Sources** Funding for camps was provided by the National Youth Science Foundation in cooperation with the West Virginia Higher Education Policy Commission

Technical Session 12: Rodents & Quaternary Mammals (Friday, November 4, 2022, 1:45 PM)

TREATING THE PRESENT AS THE PAST: ITERATIVE MODELING OF MODERN GRASSLAND

RODENT DIETS FROM STABLE ISOTOPE ANALYSES TO CONSTRAIN INTERPRETATIONS OF ISOTOPIC DATA FROM FOSSILS

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Stable isotope studies of the ecology of extant mammalian herbivores in grassland ecosystems can rely on knowledge of the isotopic composition of local food resources, and analyses of proteinaceous tissues that provide both $\delta^{13}\text{C}$ (C_3 v. C_4 resources) and $\delta^{15}\text{N}$ (trophic level) values. Paleocological studies of pre-Quaternary fossils generally analyze bioapatite that provides $\delta^{13}\text{C}$, but not $\delta^{15}\text{N}$ values, collapsing interpretation to C_3 v. C_4 derived resources with an overprint of habitat variability. This is particularly confounding for species with mixed or omnivorous diets, such as rodents, that consume not only plants but also invertebrates or small vertebrates that are primary or intermediate consumers themselves. Here we use a Bayesian mixing model and a dataset of 173 isotopic analyses of hair of three modern rodents each in distinct dietary categories (granivore, omnivore, invertivore) from two prairie habitats in SW Kansas. We explore how interpretations of rodent diets change when only $\delta^{13}\text{C}$ values are used in the model, and when invertebrate prey are treated as dietary proportions of C_3 v. C_4 derived carbon in the model. The latter (or paleo) model is most comparable to paleocological studies that rely on bioapatite analysis and cannot directly distinguish carbon contributions from plants and other dietary sources, such as invertebrates. In the mixing model without $\delta^{15}\text{N}$ (with only $\delta^{13}\text{C}$) values, all three species have similar estimated dietary proportions of C_3 and C_4 derived carbon as in the full modern model with $\delta^{15}\text{N}$ values included. Therefore, in this system $\delta^{15}\text{N}$ values do not help C_3 and C_4 diet sources. In the paleo model, which converts invertebrate consumers to equivalent plant carbon (and does not account for tissue routing of dietary protein), dietary estimates include more C_4 derived carbon as the large fraction of invertebrate carbon derived from C_3 is not recognizable. Thus, dietary reconstruction for strictly herbivorous fossil species is likely accurate when using only $\delta^{13}\text{C}$ values of bioapatite, but for intermediate and higher-level consumers in mixed C_3 - C_4 habitats bioapatite $\delta^{13}\text{C}$ values may overestimate the C_4 fraction of diet.

Funding Sources NSF-ELT Grant, Award Number: 1338262

Technical Session 14: Squamates & Turtles (Friday, November 4, 2022, 1:45 PM)

RUNNING WITH THE DEVILS: POSTCRANIAL OSTEOLOGY OF THE ENIGMATIC JURASSIC PARVIRAPTORID SQUAMATES, AND THEIR

IMPLICATIONS FOR THE EVOLUTION OF THE SNAKE BODY FORM.

Head, Jason J.¹, Benson, Roger², Evans, Susan³

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The origin of snakes and the ecological contexts for the evolution of the snake body form remain among the most contentious topics in vertebrate evolution. Most fossil data are derived from comparatively well-preserved snake specimens that indicate body form evolution by the Cenomanian. However, earlier records of purported stem snakes have been based on limited, phylogenetically ambiguous, specimens. These include the late Jurassic-Early Cretaceous parviraptorids, which were originally recognized as either anguimorph or gekkotan. The most recent body form reconstructions for parviraptorids posited an elongate, snake-like axial body with external hind limbs.

We report new data on parviraptorid postcranial anatomy, based on reanalysis of *Diablophis gilmorei* from the late Jurassic Morrison Formation of Colorado and a new specimen from the Middle Jurassic of Scotland, based on high-resolution micro C-T imaging. We evaluate the hypothesis that parviraptorids are stem snakes, as previously suggested from a limited analysis of cranial characters primarily associated with tooth implantation and a suite of vertebral characters purportedly shared with unambiguous Cenomanian snakes. Reanalysis indicates that majority of snake vertebral characters previously identified are not present: Synapophyses are not differentiated to a greater degree than in other squamates, prezygapophyses are high-angled as in non-snake squamates, there is no constriction at the base of the condyle, and zygosphenes-zygantrum articular facets are absent in *Diablophis*. Comparisons of both parviraptorids to a broad sample of squamates demonstrate that additionally recognized snake characters are plesiomorphic for more inclusive clades. Intracolumnar variation in vertebral morphology is similar to that of short-bodied, generalized squamate body forms, as is the presence of forelimbs, a large pelvis and a large robust hindlimb, represented by an elongate femur and tibia, as well as metatarsals and likely phalanges. These characters indicate that parviraptorids lacked a snake-like postcranial anatomy, likely retained a more generalized “lizard” locomotory mode and ecology and are therefore uninformative with respect to snake body form origins.

Funding Sources JJH was funded by Natural Environment Resource Council Grant (NE/S000739/1).

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

LOCATING SUBSURFACE FOSSILS USING STATISTICAL ANALYSIS OF GAMMA DETECTION

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During the process of fossilization, a higher proportion of available radioactive elements can mineralize into bone microstructure largely due to apatite's affinity for uranium and rare earth elements. In certain geological circumstances and formations, the proportion of gamma radiation from fossilized bone under the surface is distinctly higher than that of the surrounding matrix, making it possible to detect fossils without surface exposure. These high gamma counts could be used as a guide for excavation, saving time and effort on prospecting.

Here we present techniques for detecting such fossils under the surface, leveraging lightweight electronic and computer components driving a cluster of gamma detecting nodes. The Beautiful Analytical Bone Sensor (BABS) is an assembly of six gamma tubes for detecting radiation, driven by microcontrollers and working individually and in clusters to capture collections of radiation. They start by establishing a baseline sample representing the local background radiation, to which they compare subsequent readings in areas of interest using statistical analyses. The output is a table of z-scores and Poisson probabilities representing the likelihood of a fossil present in the substrate underlying the detector.

The immediate result in the field is a rough guide of recommended digging locations, based on variations in radiation levels. In post-processing, we can turn the readings into a heat map of recorded confidence scores that can be manipulated to exclude values under a certain threshold. Then, it can be refined into a more precise guide for further exploration. Testing in a controlled lab environment demonstrated that 2.4 Ma fossilized camelid limb bones from the 111 Ranch Beds in Graham County, AZ, can be detected with 95% confidence under more than 30 cm of matrix with a two-node detector. In the field, we have been able to reliably detect the locations of fossils we knew to be under the surface, and created heat maps of nearby locations to guide future excavation efforts.

Recent improvements to BABS include larger gamma detecting tubes to give it greater sensitivity. Future upgrades in consideration are: plastic shielding to filter out other radionuclides, which may fluctuate more erratically than gamma radiation and may be a confounding factor in the detector's accuracy; and adjustable supports to keep the detector evenly leveled over rough ground.

DIMINUTIVE HYBODONT CHONDRICHTHYANS FROM THE LOWER TRIASSIC OF SOUTH AFRICA AND IMPLICATIONS FOR RECOVERY OF NONMARINE ECOSYSTEMS DURING THE EARLY TRIASSIC

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Hybodont chondrichthyans are a common component of Mesozoic microvertebrate faunas, and are often recovered as an aquatic component of nonmarine assemblages, especially in Laurasia. However, Early Triassic hybodonts are rare and limited to marine occurrences in Spitsbergen, China, Oman, and Russia, with nonmarine occurrences in Angola and South Africa. Here we revise the freshwater hybodont assemblage from Driefontein, South Africa, where some teeth were previously assigned to *Lissodus africanus*. Based on a collection of hundreds of teeth, some complete with roots, we interpret the Driefontein assemblage as preserving three hybodonts—*Lissodus* n. sp., *Polyacrodus* sp., and a third taxon with superficially *Lissodus*-like teeth with exceptionally tall central cusps. There are also dozens of fin spine fragments and several cephalic spines assignable to *Lissodus* sp.

The new species of *Lissodus* is the most abundant at Driefontein, represented by hundreds of teeth from multiple tooth positions. All tooth crowns are extremely small (≤ 2.5 mm long and 1.5 mm high). The central cusp is low, pointed, and connected to the labial peg by a vertical ridge. The labial peg varies from weakly to strongly developed and can be oblique to the crown. Strong labial nodes are evident on the flanks of the peg. The preserved roots are <50% of crown height. A single tiny (1.6 x 0.7 mm) jaw fragment includes 14 teeth in parts of four tooth whorls. Specimens of *Polyacrodus* sp. are rarer ($n < 50$), larger (up to 4 mm length) and more robust. The crowns are asymmetrical in labio/lingual view, with the “central” cusp offset. There is one lateral cusp on each side, with the one closest to the central cusp better defined and more robust. Unlike the *Lissodus* teeth the crowns are strongly ornamented, with ridges extending basally from the central ridge. The third taxon is rare ($n < 15$) and has the relatively unornamented crowns of *Lissodus* but a single tall central cusp more reminiscent of *Hybodus* and some species of *Polyacrodus*.

All recovered chondrichthyan fossils from Driefontein are diminutive. Given the large sample size of hybodonts (>300) and of vertebrate fossils of many sizes (>10,000) from the lag that yielded the chondrichthyan fossils, this is not an artifact of sampling. We consider it possible that these hybodonts, which are among the oldest known freshwater Mesozoic hybodonts,

may represent miniaturization in response to the Permo-Triassic extinction event.

Funding Sources Fulbright FLEX Global Scholar Award

Technical Session 15: Theropods (Saturday, November 5, 2022, 8:00 AM)

QUANTITATIVE TESTING OF EGGSHELL ORNAMENTATION CATEGORIES WITHIN A CLUTCH OF DINOSAUR EGGS (ELONGATOOLITHIDAE) FROM THE CEDAR MOUNTAIN FORMATION (CENOMANIAN) OF UTAH

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Quantitative measures of surface variation are commonly used to analyze dentition. More recently, their efficacy has been demonstrated in differentiating the topography of extant (emu) and extinct (oviraptorosaur) theropod eggshells. However, to date, quantitative metrics of eggshell ornamentation have not been widely applied, thus their potential for advancing studies on theropod reproductive ecology and more broadly, the field of ootaxonomy, remains largely unknown. Using a recently discovered clutch of elongatoolithid eggs from the Mussentuchit Member of the Cedar Mountain Formation in Utah, we tested the quantitative variation of external eggshell ornamentation across a single oviraptorosaur nest. We sampled and created high-resolution, three-dimensional models via μ CT scans of current categorizations of elongatoolithid ornamentation types (e.g., dispersituberculate, lineartuberculate) from within the clutch. Scans were discretized into uniform, 5mm-radius, 8,000 triangle-face surfaces using Avizo, GeoMagic Studio, and MeshLab. We collected data on the variation in topographic complexity (Dirichlet Normal Energy) and relief (Slope) using the r package molaR, to test if grossly-observed differences between the current ornamentation types, and thus the differences in eggshell texture across a clutch, were borne out by the quantitative data. Our results demonstrate that DNE and Slope criteria can be used to distinguish between and within ornamentation types. DNE values for the most complex sagnetuberculate-type were an order of magnitude greater than those for the simplest dispersituberculate-type, and dispersituberculate-type values could vary by 300%. This is the first known study to quantitatively record ornamentation variation across a nest of fossil eggs. Applied with gross observation, these numeric criteria provide a new layer of descriptive granularity that could better interpret historically enigmatic ootaxa within Elongatoolithidae, with potential future use in ootaxonomic descriptions and diagnoses.

Funding Sources This material is based upon work supported by the National Science Foundation under Grant FRES-1925973

Colbert Prize Session

EARLY ORIGINS OF THE GENUS *HOMO*: TAXONOMIC AND PHYLOGENETIC ASSESSMENT OF KNM-ER 5431

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The scarcity of hominin fossils discovered in east Africa from 2.0–3.0 million years ago (Ma) is a significant barrier to the study of the origins of our genus, *Homo*. Despite this, resolving the evolution of our ancestors is not out of reach. Even very incomplete specimens for which comparable finds may be unavailable are potentially informative. This is especially so in cases where analytical methods were not sufficiently developed at the time of their discoveries.

This study reexamines the KNM-ER 5431 fossil from the Koobi Fora Formation of Kenya. It is a well-preserved set of associated but isolated teeth from 2.7–3.0 Ma. Originally it was categorized only as Homininidae sp. et. gen. indet.; thus, it has not been sufficiently considered despite being excavated decades ago.

By using geometric morphometric techniques together with cladistics analysis, the fossil is now taxonomically attributable at the genus level and can be coarsely situated phylogenetically among other archaic hominins. These results support the inclusion of KNM-ER 5431 within the *Homo* hypodigm.

Funding Sources Supported in part by the Angela Peterson Memorial Scholarship fund

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

A COMPREHENSIVE META-PHYLOGENY OF ALL NON-MAMMALIAFORM SYNAPSIDS: NEW TOOL FOR STUDIES OF MACROEVOLUTION IN THE FORERUNNERS OF MAMMALS

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A large phylogenetic tree is a critical component of comparative analyses that examine broad macroevolutionary

patterns, such as the tempo and mode of evolution or morphological disparity through time. However, the sample of species included in published phylogenies rarely aligns with the species that researchers wish to examine in comparative analyses. For instance, early synapsid phylogenies often focus on specific subclades, such as pelycosaur or anomodonts, rather than broadly encompassing all known synapsid lineages, thus hindering analyses that require detailed sampling across synapsid lineages. To address this issue, we generated a time-calibrated meta-phylogeny ('metatree') of synapsid species from the Carboniferous through the Eocene (305–34 Ma). The metatree approach uses source character matrices (rather than source trees) and generates complete sets of most parsimonious trees, combining them rather than generating a single consensus tree. We incorporated 269 published morphological character matrices, which includes every non-mammaliaform synapsid character matrix that has ever been published (as of July 2021) and 57 mammaliaform-focused matrices. Due to evolving ideas of relationships and frequent matrix reuse, each of the matrices was weighted according to its publication year and its dependence on 'parent' matrices using an established metatree procedure. The metatree approach relies on XML metadata files that reconcile taxon names to valid Paleobiology Database taxa (PBDB). Because the metatree approach utilizes PBDB taxonomy, we vetted the PBDB information and made approximately 500 additions and corrections to taxon information. The resulting metatree includes 2,128 synapsid species, making it one of the largest fossil phylogenies ever produced. Approximately 1600 species are non-mammaliaform synapsids, and the remaining ~525 species are mammaliaforms, including many of the known Mesozoic and early Cenozoic mammaliaforms. The massive taxonomic and temporal breadth of the metatree make it broadly applicable to studies on synapsid macroevolution. The past decade has witnessed a resurgence of research on non-mammaliaform synapsids, and our new, comprehensive metatree provides a rigorous foundation for continuing work on macroevolutionary patterns and processes among the forerunners of mammals.

Funding Sources NSF DEB-1754502, NSF DBI-1812126

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

A NEW LATE CARBONIFEROUS (GZHELIAN) ARAEOSCELIDIAN (REPTILIA, DIAPSIDA) FROM THE BIRTHDAY BONEBED, HALGAITO FORMATION, BEARS EARS NATIONAL MONUMENT, UTAH, USA

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Araeoscelidians are a clade of small, lightly built, diapsid reptiles known by only two taxa from the late Paleozoic of Europe and four from North America. All are terrestrial except for the aquatic *Spinoequalis schultzei* from the late Carboniferous (Gzhelian) of Kansas, USA. An undescribed genus and species of Gzhelian araeoscelidian is represented by numerous specimens, including an ontogenetic series, from the Halgaito Formation, Valley of the Gods, Bears Ears National Monument, southeastern Utah. The specimens occur in a multitaxic bonebed discovered in 1989 that was deposited as a discrete sedimentologic unit in the lower portion of the formation in a fluvial channel system during a flooding event. The Halgaito araeoscelidians inhabited the coastal plain on the southwestern border of the Paradox Basin in western Pangea during a relatively short wet interval when intermittent-to-perennial streams and rivers traversed it during an otherwise semi-arid to arid climate. The Halgaito araeoscelidian is an overwhelming component of the Birthday bonebed tetrapod fauna in comprising 55 percent of the five identified taxa.

To determine the relationship of the Halgaito taxon to other North American araeoscelidians (those from Europe are too poorly documented to include) and to early neodiapsids, a phylogenetic analysis was conducted using TNT. Results indicate the Halgaito araeoscelidian resolves within the monophyletic clade Araeoscelidia as the sister taxon to the early Permian (Artinskian–Kungurian) *Araeoscelis* from Texas, with the late Carboniferous (Kasimovian) *Petrolacosaurus kansensis* from Kansas and the early Permian (Asselian–Sakmarian) *Zarcasaurus tandyderus* from New Mexico forming successively more basal sister taxa relative to this clade. Unexpectedly, *Spinoequalis schultzei* resolves as a member of Neodiapsida, which is the sister clade to Araeoscelidia. Although the tree has high Consistency and Retention indices, the support for internal clades is low, except for Diapsida and Araeoscelidia, which are high and moderate, respectively. The Halgaito araeoscelidian is distinguished from the others by relative sizes of the maxillary teeth, a small contribution of the jugal to the ventral margin of the skull, and eight cervical vertebrae.

Technical Session 8: Evolutionary Developmental Biology (Thursday, November 3, 2022, 1:45 PM)

TESTING THE INHIBITORY CASCADE MODEL IN ELEPHANTS

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The Miocene–Pleistocene proboscidean trend towards larger, higher-crowned molars, with an increased number of more closely spaced plates, is a textbook example of adaptation to climatic change, reflecting increased grazing in a

cooling/drying world. Developmental constraints on molar evolution in other mammals are well documented but have received little attention in elephants. The Inhibitory Cascade Model (ICM) of molar development -- whereby relative molar size is determined by the balance of epithelial inhibitors, expressed by the anteriorly-developing molar, and mesenchymal activators -- is thought to be the plesiomorphic system for Mammalia. However, elephant molar development is unusual amongst mammals, with a horizontal-displacement mechanism of tooth succession that continues late into ontogeny (ongoing at >30 years in extant elephants). Eruption and wear occurs in tandem with tooth formation and anterior progression through the jaw, with molars forming posteriorly after the preceding molar has mineralised and erupted (and thus after inhibitory activity at enamel knot signalling centres would have ceased). Could this 'free' elephant molar morphology from the developmental constraints imposed by the ICM? Or facilitate runaway evolution in tooth size (especially in the M3), underpinning both the extreme dental morphology, and the evolutionary trends, observed in the Elephantidae? Here we investigate this by using the ratio of m2:m1, and m3:m1 molar size in three genera of elephants, the extant *Elephas*, and the extinct *Palaeloxodon* and *Mammuthus* to test whether the Elephantidae fits the established, ICM-consistent pattern of mammalian molar proportions. We show that elephants conform to the predictions of the ICM, in-line with reduced inhibitory activity along the tooth row, extending the known range of molar morphospace for extant mammals. However, they do not alter or extend the Mammalian-wide trend of molar proportions previously observed across fossil and extant taxa. Instead elephants fill the 'gap' previously observed between fossil and extant mammals and the extreme molar proportions of the extinct artiodactyls *Uintacyon*, *Elomeryx* and *Merycoidodon*. Thus both elephant molar morphology and development can be understood within the broader mammalian dental paradigm, suggesting that the evolution of horizontal tooth displacement in the Oligocene reflects heterochronic processes rather than the evolution of a *de novo* mechanism of tooth development.

Funding Sources This work was funded by a Daphne Jackson Research Fellowship to VLH.

Virtual Posters

THE RHIZODONTS OF BLUE BEACH, NOVA SCOTIA, CANADA (HORTON BLUFF FORMATION, TOURNASIAN): NEW DATA ON OCCURRENCES AND IMPLICATIONS FOR PHYLOGENY AT THE DEVONIAN-CARBONIFEROUS FAUNAL TRANSITION

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Work on the fossil tetrapods and actinopterygians of Blue Beach, Nova Scotia, revealed an interesting overlap of elements previously attributed to discrete Devonian or later Carboniferous faunas, suggesting a similar pattern may be seen among the scarcopterygians.

Rhizodonts are an early diverging, monophyletic group within Tetrapodomorpha known from the Devonian and Carboniferous of Australia, the UK, and North America. As an early diverging clade, rhizodonts are important subjects of study to understand early stages of tetrapodomorph evolution, including trends leading towards the fin-to-limb transition. Complicating our knowledge of rhizodonts is that the ten recognized genera are largely known from incomplete specimens, and species are known from non-overlapping parts of the skeleton, which limits the identification of shared traits. At Blue Beach, two taxa have been identified: *Strepsodus* and *Letognathus*. *Letognathus* was identified based on a lower jaw as occupying a basal position amongst rhizodonts, whereas the more derived *Strepsodus* was identified from isolated elements of the forefin, skull, and jaws.

Here we evaluate 25 additional specimens to expand our knowledge of the anatomical and taxonomic diversity at this important locality. Included are a lower jaw element, partial skull roof, two additional skull bones, and a partial brain case, along with isolated fin and pectoral girdle bones. We find these specimens share a mix of basal and crownward features, including a deeply interdigitating inter-postparietal suture line akin to *Barameda* but unlike the straight suture structure of *Strepsodus*, and a median extrascapular suture line akin to *Gooloogongia*, which would be consistent with what is known from *Letognathus*. The partial braincase is unique for rhizodonts, only known in *Gooloogongia* and *Barameda* but unossified in other Carboniferous rhizodonts, also suggesting an affinity to *Letognathus*. Other specimens further reinforce the presence of *Strepsodus* at the locality. There is no evidence for a third taxon. These data support the presence of a rhizodont fauna at Horton Bluff comprising of elements otherwise known from the Devonian or later Carboniferous and clarify previously unknown anatomy of the species at Blue Beach.

Funding Sources NSERC Discover Grant to JSA

Technical Session 3: Marine Reptiles (Wednesday, November 2, 2022, 8:00 AM)

THE INTERNAL BRAINCASE ANATOMY OF THALATTOSUCHUS SUPERCILIOSUS -- WITH IMPLICATIONS FOR THE ENDOCRANIAL EVOLUTION OF METRIORHYNCHID CROCODYLOMORPHS

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Thalattosuchian crocodylomorphs underwent a major evolutionary transition, evolving from semiaquatic forms reminiscent of extant crocodylians, into pelagic forms with flippers, a tail fin and smooth scaleless skin. These pelagic forms – the Metriorhynchidae – also evolved a novel suite of endocranial anatomies hypothesised to be related to living exclusively in saltwater. However, the evolution of these internal braincase structures within Metriorhynchidae is poorly understood. Herein, we describe the endocranial anatomy of *Thalattosuchus superciliosus*, the basal-most member of the subfamily Metriorhynchinae, using computed tomography (CT) data and three-dimensional models. We compared it against two already described metriorhynchids, the derived metriorhynchine *Cricosaurus araucanensis* and the basal geosaurine ‘*Metriorhynchus*’ *brachyrhynchus*. The metriorhynchines differ from the geosaurine in having less laterally expanded cerebral hemispheres, shallower flexures of the brain dorsal margin, and lacked the ventral deflection of the diverticulum ventral to the pituitary fossa chamber. Whereas the basal members of both subfamilies share a single bilobed foramen for the carotid canals entering the pituitary fossa chamber, well-defined otoccipital diverticula, and lacked the ‘extreme pelagic’ inner ear morphology. We hypothesise that basal metriorhynchids were not suited to a sustained pursuit lifestyle. Moreover, we posit that within both metriorhynchid subfamilies there was parallel evolution towards becoming pursuit predators.

Technical Session 5: Amphibians & Early Reptiles (Thursday, November 3, 2022, 8:00 AM)

CRANIAL MORPHOLOGY OF *PALAEOSPONDYLUS*

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Palaeospondylus gunni, from the Middle Devonian, is one of the most enigmatic fossil vertebrates, and its phylogenetic position had long remained unclear. To solve this problem, we examined the cranial skeleton of this species at a resolution of 1.46 μm using synchrotron radiation X-ray micro-computed tomography. Unlike previous studies, our analysis included two specimens whose cranial skeletons were completely embedded and intact within the matrices. The skeleton of *Palaeospondylus* consists solely of endoskeletal elements in

which hypertrophied chondrocyte cell lacunae, osteoids and a small fraction of perichondral bones developed. Within the otic capsule, three semicircular canals, representing a synapomorphy of jawed vertebrates, were recognizable, and the separate skeletal elements can be homologized to those of jawed vertebrate chondrocrania. The neurocranium of *Palaeospondylus* consists of the ethmosphenoid and otoccipital portions, separated by an intracranial joint. At the joint between the palatoquadrate complex and the ethmosphenoid portion, a distinct basiptyergoid process protrudes ventrally. The element articulated with the otic capsule is nothing but a hyomandibula in the morphotype of jawed vertebrates. The relative length of the hyomandibula to the neurocranium falls within the ranges of jawed vertebrates, whereas the Meckel's cartilage is relatively very small. Since the cranial morphology of *Palaeospondylus* revealed in this study corresponds to the morphotype of tetrapodomorph crania, we performed cladistic analyses using a character matrix of tetrapodomorphs. Both Bayesian and parsimony analyses supported the phylogenetic position of *Palaeospondylus* being closer to limb-bearing tetrapods than to *Eusthenopteron*. The absence of teeth, cranial dermal bones, and paired appendages in *Palaeospondylus* can be explained by noting that the morphotype of this species is comparable with the larva of tetrapods. It appears that the combination of the very small lower jaw relative to the cranium and the larval-like body plan had hitherto been an obstacle to the classification of *Palaeospondylus*.

Funding Sources JSPS KAKENHI grant numbers JP17K18354 and JP17H06385.

Symposium: International Community Connections
(Wednesday, November 2, 2022, 1:45 PM)
USING A VIRTUAL CONSTRUCT OF THE PERMIAN KAROO SUPERGROUP TO TEACH HIGH SCHOOLERS FIELD SURVEY SKILLS, BIOSTRATIGRAPHY, AND EVIDENCE-BASED PROBLEM SOLVING

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Over the past two years, the relevance of virtual tools in education has grown immensely. These resources can and should remain in our educational toolboxes, as they increase student opportunity access. New research shows broadening accessibility and inclusivity of field learning improves learning outcomes for students. Using interactive virtual learning resources in geology and paleontology education expands accessibility to learn traditionally-considered field skills. A virtual geological field area functions as a conventional outdoor geologic locality, engaging students in comparable ways by combining field data collection,

information synthesis, and stratigraphic analysis. For our online course, we built a geologically-detailed virtual paleontology field area providing students the necessary setting to learn paleontology field surveying skills. Students involved in this two-week program were upper-level high school students.

Here we present outcomes of using a virtual construct of the Permian portion of the Karoo Supergroup built in the virtual platform GatherTown. This virtual world system allows learners to interact with built-in data and media (applicable descriptive geologic data and fossil images), educators, and peers. We focused on three key skills: field surveying, biostratigraphic analysis, and evidence-based problem-solving. Equally important, we sought to increase the enjoyability of online learning, which is crucial for maintaining engagement and new information synthesis. Students created overhead maps and detailed stratigraphic columns of the entire area, exploring the virtual environment and collecting data collaboratively or individually. These stratigraphic columns and maps were extremely high quality, comparable to university sophomore and junior geology majors. 86% of students (N=7) reported the virtual space helped them learn course content and feel more excited about geoscience and paleontology. Both parents and students viewed this virtual space very positively, with 89% of parents (N=9) and 100% of students reporting high favorability (rankings of 8-10 on a 1-10 scale). This virtual paleontology field site increased the effectiveness of our online course, and provided an environment where students successfully learned essential field skills. We will continue developing these resources for new localities, adding features to refine pedagogical underpinnings and applications for accessible online earth and life science learning.

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

INNER EAR MORPHOLOGY OF AN EARLY CRETACEOUS EUTRICONODONTAN FROM THE CLOVERLY FORMATION (MONTANA, USA)

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We present the inner ear of a eutriconodontan represented by three skulls from the Lower Cretaceous Cloverly Formation. The specimens were collected nearly 50 years ago and although they have not been formerly described they have been referenced in the literature as the 'Cloverly triconodont' or 'Early Cretaceous triconodont'. We provisionally assign the specimens to *Astroconodon* sp. Although several well-preserved crania are known for Eutriconodonta, *Astroconodon* represents only the second digital reconstruction of

eutriconodontan inner ear morphology, the other being that of *Priacodon*. Similar to *Priacodon* and other eutriconodontans, *Astroconodon* exhibits several features of the bony labyrinth that are plesiomorphic for mammaliaforms, including the absence of a primary osseous lamina, cribriform plate, and osseous cochlear ganglion canal. However, *Astroconodon* has a well-developed base of the secondary osseous lamina, which extends almost the complete length of the cochlear canal, similar to that of *Priacodon* and the zhangheotheriid *Origolestes*, but in contrast to cladotherians. The cochlear canal is straighter and more slender in *Astroconodon* and other eutriconodontans than that of a number of basal mammaliaform clades, which exhibit varying degrees of gentle cochlear canal curvature. The anterior and posterior semicircular canals form a primary crus commune. A secondary crus commune is absent. *Astroconodon* had an extensive circum-promontorial plexus surrounding the cochlear canal. Several transcochlear sinuses crossed the cochlear canal transversely on the ventral (hypocochlear sinus) and dorsal (epicochlear sinus) aspect of the cochlea. The hypocochlear sinus formed a network of canals at the base of the cochlea, with several small canals passing within the secondary lamina base anteriorly. However, none of those canals open into the cochlear canal, differing from the circum-promontorial plexus in *Morganucodon* and *Borealestes*. Similar to *Priacodon*, a posterior epicochlear sinus was present but not an anterior epicochlear sinus. By contrast, *Morganucodon* and *Borealestes* retained both sinuses. The epicochlear and hypocochlear sinuses anastomosed along the lateral margin of the cochlear canal where they connected to the prootic sinus. The inner ear of *Astroconodon* highlights that the evolution of the secondary lamina base and coiling of the cochlear canal is not linear, with different mammalian clades following their own evolutionary trajectory.

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

NEW DATA ON THE ANATOMY AND IDENTITY OF MOR 660 (THEROPODA: DROMAEOSAURIDAE)

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Saurornitholestes langstoni is an enigmatic dromaeosaurid from the Late Cretaceous of North America. The holotype specimen is quite fragmentary, but several referred specimens are substantially more complete.

An often referred specimen is MOR 660, a partial postcranial skeleton from the Campanian Two Medicine Formation of Montana that includes humerus, radius, ulna, both tibiae, a fibula, the sacrum, ilium, large portions of both of the feet and hands, and most of the cervical and dorsal vertebral column, including the atlas and axis. However, this specimen has never

been described, and its identity as *Saurornitholestes langstoni* is uncertain given its limited overlap with the diagnostic elements of the holotype.

Recently, a complete skeleton confidently referable to *Saurornitholestes langstoni* was discovered in the Dinosaur Park Formation. While this specimen is still under study, we can conduct limited observations to test the long-accepted referral of MOR 660 to *Saurornitholestes langstoni*. We note differences such as a more sharply pointed preacetabular process of the ilium in MOR 660, along with a strongly hooked ventral projection of the preacetabular process. Further comparisons are made to the referred specimen TMP 88.121.39, including several character differences in the humerus, such as a better developed humeral head, a more strongly bowed humeral shaft, and weaker entepicondyle in MOR 660 relative to TMP 88.121.39.

We present a comprehensive reinterpretation of the postcranial anatomy of MOR 660, noting phylogenetically significant characters throughout the postcranium. We score MOR 660 in several phylogenetic matrices to present an independent appraisal of its phylogenetic position relative to the holotype and other referred specimens of *Saurornitholestes langstoni*. Future comparisons with other putative *Saurornitholestes langstoni* specimens, combined with these results, will be instrumental in determining whether MOR 660 is likely to represent this species or a new taxon. The identity of this specimen has implications for the standing biodiversity of dromaeosaurid theropods in Late Cretaceous terrestrial ecosystems.

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

ON A NEW CHAOYANGOPTERID PTEROSAUR SPECIMEN FROM THE LOWER CRETACEOUS CRATO FORMATION (ARARIPE BASIN, NE BRAZIL) WITH IMPLICATIONS ON THE INTRARELATIONSHIPS AND PALEOBIOGEOGRAPHY OF THIS CLADE

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Chaoyangopterids comprise a lineage of azhdarchoid pterosaurs basically characterized by synapomorphies found in the skull such as a nasoantorbital fenestra extending dorsal to the orbit and the dorsal margin of the skull concave (excluding cranial crests). However, they can also be distinguished by showing elongated mid-cervical vertebrae (length less than 3 times the width) with very low neural spines, which differentiates them from azhdarchids and alanqids, among

other azhdarchoids. The most complete specimens belonging to the Chaoyangopteridae are from Liaoning (NE China), but some new finds also show their presence in Morocco and Brazil, as well as presumably in Argentina. The presence of this clade in Brazil has been discussed since the description of the incomplete and fragmentary skull of *Lacusovagus magnificens* and other postcranial remains from the Aptian Crato Formation (Araripe Basin), which was strengthened by subsequent postcranial findings of uncertain chaoyangopterids. Here we present a new specimen consisting of several mid-cervical vertebrae housed at the Universidade Regional do Cariri (URCA), which fit the morphology observed in chaoyangopterids further supporting the hypothesis on the presence of this clade in the Lower Cretaceous of Northeastern Brazil. The absence of a lateral foramen in the mid-cervicals, a trait shared by azhdarchids and chaoyangopterids but not by other azhdarchomorphs, is also discussed. The phylogenetic analysis performed here recovered *Lacusovagus* in a trichotomy with *Chaoyangopterus zhang* and *Jidapterus edentus*, well-nesting within the lineage sharing the lateral flaring of the jawline as a synapomorphy. After a review of specimens from other localities, the presence of chaoyangopterids in the Cretaceous global fossil record seems to be further beyond than the aforementioned, which suggested that Chaoyangopteridae was a cosmopolitan lineage of azhdarchoids during the early-to-mid Cretaceous.

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Symposium: International Community Connections
(Wednesday, November 2, 2022, 1:45 PM)

ALL ABOARD THE STEAM BUS WITH DINOSAURS AND CAVEMEN

Holliday, Casey, Lessner, Emily, Lawrence, Austin, Cranor, Corrine, Lagorio, Amy, Sellers, Kaleb, Fields, Mara, Wilken, Alec, Sullivan, Samuel, Middleton, Kevin, Ward, Carol

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Few subjects inspire K-12 student interests in STEM topics like Anatomy and Paleontology. Fossils, animals and physiology naturally draw inquisitive people to discover how the planet, environment, and its living beings interact with one another over time. Folks from rural and underprivileged areas like the Mid-Missouri region are often unfamiliar with scientific concepts as well as scientist role models compared to those from more privileged populations. These barriers ultimately lead to a decrease in the diversity of people participating in the scientific endeavor. To better engage with these populations, our Integrative Anatomy Program has collaborated with numerous community partners throughout Mid-Missouri to share science and introduce the public to the scientists themselves. Here we share some of those experiences.

Our NSF-funded education initiative “Dinosaurs & Cavemen Science Expo” has proven immensely successful during its 12-year run. This pop-up Natural History museum is set in a local high school with a planetarium, filled it with three dozen activities and 50 volunteers from around campus and the community, and was visited by nearly 1200 people each day. A diaspora of resources and people from the expo have since been mobilized to other regional activities including Science Cafés, Science-on-Wheels, and Campus events. Additionally, our comfort with public education enabled us to translate the Expo back to science as an Open House where we invited the public to our research labs just prior to Covid Quarantine.

Moving forward, we have partnered with the Columbia Public Schools STEM Alliance and the STEAM Bus, a renovated school bus rigged with solar power, computers and other gear. We have adapted several of our Dinosaurs and Cavemen Science Expo activities to this mobile museum and are visiting key communities including the City of Refuge, Farmer’s Market and Family Fun Fest. Within the bus, learners are met with a narrative-based journey through multi-level educational activities stemming from our research programs including digging, mapping and interpreting 3D printed dinosaur skeletons and exploring East African field sites and hominin musculoskeletal evolution. Learners are met with tablet-mediated quizzes before and after participating to gauge engagement and knowledge. We anticipate these interactions will prove valuable as community outreach activities as well as science communication training for our students and faculty.

Funding Sources NSF IOS 1457319; NSF EAR 1631684

Technical Session 6: Dinosaur Macroecology & Macroevolution (Thursday, November 3, 2022, 1:45 PM)

BREAKING THE MACROPREDATORY MOLD: NON-PREDATORY THEROPOD DINOSAUR ECOMORPHOLOGY AND MACROEVOLUTION

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Previous comparative morphometric analyses of the theropod dinosaurs has concentrated on taxa which retained the ancestral flesh-eating habit of this clade. Such work has been helpful in elucidating the different role of various aspects of the ecomorphology of dinosaurian predators. However, the theropods include numerous subgroups which evolved into new trophic modes which include the ceratosaurian noasaurids and diverse coelurosaurian clades (ornithomimosaurs, alvarezsaurids, therizinosaurs, oviraptorosaurs, and avialians). Additionally, the phylogenetically problematic Late Jurassic dinosaur *Chilesaurus* might be an additional non-predatory theropod.

Measurements of the teeth (where present), skulls, forelimbs,

unguals, pelvis, tail, and hindlimb of non-predatory theropod taxa were incorporated into previously developed empirical morphometric analyses. Non-predatory theropods occupy different parts of the morphospace occupation by their carnivorous kin; however, rather than a single “non-predatory” field, the various non-faunivores occupy different parts of this space. Several of the Cretaceous non-predatory clades are particularly speciose. The possibility that a trophic shift within these clades might have favored a change in speciation rate is examined. On a species-level supertree of Theropoda there is moderate statistical support for increased rates of speciation in Oviraptorosauria and early Avialae. However, this signal might reflect taphonomic rather than evolutionary patterns, in that these taxa are well represented in Lagerstätten in which many predatory clades are absent. When comparisons are restricted only to other clades with representation in Lagerstätten deposit (e.g., Deinonychosauria), or when species known only from these deposits were excluded, the support for increased rates of speciation in non-predatory groups is reduced.

Technical Session 3: Marine Reptiles (Wednesday, November 2, 2022, 8:00 AM)

MOSASAUR MEMOIRS: ECOLOGICAL SIGNALS DERIVED FROM DENTAL MICROWEAR AND GEOCHEMICAL ANALYSIS IN ALBERTAN BEARPAW FORMATION MOSASAURS

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The mosasaurs of the Campanian Bearpaw Formation of southern Alberta, representing the northwest part of the Western Interior Seaway, consist of *Tylosaurus* sp., *Mosasaurus missouriensis*, *Prognathodon overtoni*, and *Plioplatecarpus primaevus*. The same strata also yield elasmosaurs, turtles, *Enchodus*, sharks, sawfishes, cuttlefishes, lobsters, ammonites, and shellfish. Well-preserved mosasaur specimens from this formation have been studied before, but their ecological interrelationships, as well as those with other (in)vertebrates from the Bearpaw Sea, have not received significant attention.

In order to explore possible feeding preferences and trophic levels of these Bearpaw Sea inhabitants, two-dimensional microwear analysis was performed to the most common and well-preserved mosasaur teeth via scanning electron microscopy, in conjunction with strontium/calcium content, measured via energy-dispersive x-ray spectroscopy. Strontium (Sr) content is depleted with every upwards foodchain step, since calcium (Ca) is preferentially absorbed, therefore providing a tool for relative trophic levels.

The microwear analysis suggests *Prognathodon* ate harder-bodied prey, whereas *Plioplatecarpus* preferred softer-bodied prey, and *Mosasaurus* displays an intermediate microwear

signal. These preliminary results are supported by the Sr/Ca analysis: the Sr/Ca content in *Prognathodon* teeth matches the durophagous sawfish, *Plioplatecarpus* overlaps with elasmosaurs and sharks, and *Mosasaurus* overlaps with all aforementioned. The results therefore suggest *Plioplatecarpus* and *Prognathodon* partitioned resources, whereas *Mosasaurus* was likely an opportunist/generalist.

An additional carbon and oxygen isotope analysis (proxies for diet/diving depth and salinity) interestingly found the narrowest $\delta^{13}\text{C}$ range (i.e. diving depth) in *Mosasaurus*, and wider ranges for *Prognathodon* and *Plioplatecarpus*; the latter also showing overlap with elasmosaurs. The mosasaur and elasmosaur $\delta^{13}\text{C}$ range overlaps with *Enchodus*, but differs from sharks and sawfish.

The mosasaurs, elasmosaurs, fish, lobsters and cuttlefish share a roughly similar $\delta^{18}\text{O}$ range. *Prognathodon*, however, shows more positive values, which overlap with those of shellfish. Higher $\delta^{18}\text{O}$ values indicate different salinities, suggesting a different foraging area for *Prognathodon*, which is also supported by its higher $\delta^{13}\text{C}$ range. Therefore, the Bearpaw mosasaurs appear not only to have employed dietary partitioning, but also habitat partitioning.

Funding Sources Femke Holwerda is the Dr Betsy Nicholls Postdoctoral Research Fellow at the Royal Tyrrell Museum of Palaeontology, funded by the Royal Tyrrell Cooperating Society

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

THE NEED FOR BROADER APPLICATION OF "DOBZHANSKY'S RULE" TO PALEOECOLOGICAL STUDIES

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Dobzhansky's famous declaration of the fundamental importance of evolution to all aspects of biology is worth remembering when studying paleoecology. Paleoecological studies aiming to document aspects of the environment or of the autecology of individual species commonly measure proxies from fossil specimens, assuming that these proxy measurements on various species are independent of one another, in spite of the knowledge that they are evolutionarily related to varying degrees. Recent studies of paleoecological proxies using phylogenetic comparative methods have shown important degrees of phylogenetic signal in almost every case in which it has been sought. Dental microwear and mesowear, morphology of the teeth, cranium, and postcranium, and even geochemical proxies such as stable isotopes have been shown to be affected by evolutionary history.

Statistical methods for accounting for phylogenetic signal

have proliferated in recent years, but their use in paleoecological studies remains limited. Arguments against incorporating evolutionary history in paleoecological studies have often cited the paucity of phylogenies that include fossil taxa; not only is this increasingly untrue as more clades are subjected to phylogenetic analysis, but it has been shown that even using a tree based on taxonomy rather than a phylogenetic analysis can improve the predictive power of biological analyses.

While it is true that there are cases where phylogenetic signal is small relative to the influence of ecology, this is an assertion that needs testing, not an assumption that can consistently be made. Failing to account for evolutionary signal in paleoecological data or, worse, claiming without evidence that it just isn't there, is likely to yield misleading results.

Funding Sources This work was funded in part by National Science Foundation grant DEB-1256897 to S.S.B.H.

Technical Session 18: Birds (Saturday, November 5, 2022, 1:45 PM)

NEW BASAL ANSERIFORMES FROM THE EARLY PALEOGENE OF NORTH AMERICA AND EUROPE

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We describe nearly complete skeletons of basal Anseriformes from the Late Paleocene to Early Eocene of North America and Europe. Collectively, these birds appear to be representative of the most basal Anseriformes near the divergence of Anhimae (screamers) and Anseres (typical 'duck-like' waterfowl), but their positions relative to these clades are not clearly resolved by phylogenetic analyses. A new family is erected for one of the fossils, with which the others share similarities but to which they cannot be confidently assigned. The new fossils augment a growing assemblage of late Cretaceous to earliest Paleogene pan-Anseriformes that include many of the oldest known Neornithes, in concordance with phylogenomic and timetree analyses of extant Aves. Although the typical 'duck-like' spatulate bill of Anseres is clearly a derived state among Aves, a central controversy is whether the fowl-like bill of Anhimae represents a reversal to a primitive state within Anseriformes. This hypothesis is couched in what have been interpreted as vestigial bill lamellae in screamers (used for filter feeding in ducks), the antiquity of presbyornithids (the type, *Presbyornis* Wetmore, 1926 exhibits a duck-like bill), and a minority of phylogenetic analyses that nest screamers higher among Anseriformes than presbyornithids and other stem Anseriformes. The new family is similar in some aspects of both cranial and postcranial anatomy to other well-represented early Paleogene Anseriformes and members of Anseres, such as *Presbyornis*. However, its more fowl-like bill morphology, unlike the spatulate bill of Anseres, suggests feeding and

ecological differences more akin to those of Anhimae. To the extent that its feeding apparatus is intermediate between those of Anhimae and Anseres, it does not provide clear evidence of whether these are early stages in the evolution of either or representative of a primitive grade of stem-Anseriformes that was ancestral to both. Additional specimens of similar basal Anseriformes of uncertain affinities from the early Eocene of North America and Europe further complicate interpretation due to the mosaicism of primitive and derived characters they exhibit. Resolution of character state evolution on the path to or within crown-Anseriformes will depend on better characterization of what is increasingly apparent to have been a very large and diverse collection of basal lineages of which we currently have only the most cursory representation.

Symposium: International Community Connections
(Wednesday, November 2, 2022, 1:45 PM)

THE DISCOVERIES IN GEOSCIENCES (DIG) FIELD SCHOOL: CONNECTING TEACHERS WITH RESEARCHERS AND MUSEUMS TO INSPIRE STUDENTS WITH REAL SCIENCE IN THE CLASSROOM

Hovatter, Brody T.¹, Wilson Mantilla, Gregory P.¹, Canning, Katharine², Leatherman, Devin²

¹University of Washington, Seattle, Washington, United States, ²Burke Museum, Seattle, Washington, United States

The Discoveries in Geosciences (DIG) Field School is a non-profit, professional development program for K-12 teachers created by University of Washington Burke Museum paleontologists. The mission of the DIG is to connect K-12 STEM (Science, Technology, Engineering, and Math) teachers with scientific research, scientists, and museums through ongoing training in paleontology and geology and related curricula for their classrooms. The program began in 2010 with seven local Montana teachers and has since served over 250 teachers from 31 states, South Korea, and Canada and reached over 25,000 students.

Central to the DIG is a four-day, hands-on, immersive field experience for teachers at an active research site in the Hell Creek badlands of northeastern Montana. Teachers are instructed in and engage in paleontology and geology activities that directly contribute to our field research while simultaneously drawing connections between the ongoing research on the Cretaceous-Paleogene mass extinction and relevant cross-cutting concepts and scientific practices of the Next Generation Science Standards (NGSS). The field school is the capstone experience of the DIG, but the program extends beyond the time spent in the field by providing teachers ongoing educational support throughout the school year. We do this through a variety of methods including specialized curriculum development and education tools (e.g., our traveling “museum in a box”), online lesson plans that implement the current NGSS, and classroom and museum visits. Further, these educational resources provide authentic

community science opportunities for classrooms whereby they help collect and analyze data that contribute to our active research and become permanent records in the Burke Museum of Natural History and Culture vertebrate paleontology collection. As such, the DIG has grown into an effective model for combining scientific research and museum resources to provide a powerful educational outreach program for promoting science as a process among teachers and their classrooms.

Preparators' Poster Session

A METHOD FOR SEPARATING THE RHAMPHOTHECA FROM THE SKULL IN TURTLES THAT KEEPS BOTH BONE AND KERATIN INTACT.

Huang, Ferrania S., Shipps, Brenlee, Peacock, Brandon R.

Biological Sciences, Idaho State University, Pocatello, Idaho, United States

Tooth loss has evolved convergently in many disparate taxa, and it is often accompanied by the development of a keratinous beak or rhamphotheca. Though this structure informs a great deal about an animal's diet and ecology, keratin is rarely preserved in the fossil record. Consequently, we must ground-truth our understanding of beak morphology using extant species. Ideally, specimens involved in ground-truthing would have the skull and rhamphotheca separated and intact so that the relationship between these structures can be analyzed, but the rhamphotheca is often left attached to the skull during the preparation of osteological specimens.

As part of a study on turtle beak triturating surface morphology, we established a protocol for the removal of keratin from bone, thus allowing us to compare the morphology of a turtle's rhamphotheca with that of its underlying maxilla and premaxilla. A protocol for separating turtle rhamphotheca from skull material in a manner that keeps both intact has not been made readily available. We, therefore, present our method for preparing the bone and rhamphotheca of 13 turtle specimens from the Idaho Museum of Natural History. We first soaked specimens in distilled water for 12 hours, then transferred them to 70% ethanol for several days. Next, specimens were placed in solutions of three parts 70% ethanol to one part glacial acetic acid for one hour, then rinsed in distilled water. Finally, we transferred specimens to a solution of one part porcine trypsin, one part sodium borate, and one-hundred parts distilled water for 24 hours. All steps were performed at room temperature. At the end of the 24-hour trypsin soak, intact keratin could be removed from bone with little effort.

The preparation of these specimens provided valuable data for upcoming publications. This method allows for better conservation of edentulous taxa and thus a more robust understanding of the relationship between bone and rhamphotheca. The data gathered can be used to make

predictions about keratin-bearing organisms where keratin is not preserved.

Funding Sources Idaho State University and the Idaho Museum of Natural History

Technical Session 16: Hoofed Mammals (Saturday, November 5, 2022, 8:00 AM)

MODELING NORTH AMERICAN MIOCENE HABITAT TURNOVER WITH MULTIVARIATE UNGULATE ECOMETRICS

Hummel, Rudolph, Pagnac, Darrin

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The Rapid Increase in C4 Ecosystems (RICE) was a turnover in vegetation composition which occurred in the late Miocene epoch in North America. Phytolith data suggest this turnover in vegetation type was accompanied by a transition from mosaics of partially open habitats to drier, more open grasslands and shrublands. I independently tested this hypothesis using ecometrics, which is the practice of reconstructing paleoenvironments using quantitative relationships between modern communities and environments. I used six online databases and the statistical program R to build and test eight modern ungulate multivariate ecometric models which used the body mass and hypsodonty classification of non-cetacean ungulates and calcaneal gear ratio of non-cetacean artiodactyls to estimate environmental variables during the middle to late Miocene (~16-5 Ma). These eight models varied in statistical methods (quadratic discriminant function analysis and multiple regression), geospatial datasets (global and sub-saharan African), and environmental variables (vegetation cover and mean annual precipitation (MAP)). None of the quadratic discriminant function analysis models met tests for significance, but multiple regression yielded adjusted multiple r squared values between 0.50 and 0.65 for the global precipitation model and both sub-saharan African models. I used the sub-saharan African multiple regression models (r squared > 0.6) to estimate vegetation cover and MAP for nine Barstovian (~16-13.6 Ma) and ten Hemphillian (~10.3-4.9 Ma) fossil assemblages using a combination of body mass, hypsodonty, and calcaneal gear ratio data from past publications, the New and Old World (NOW) database, and museum specimen measurements. Two-way t-tests between Barstovian and Hemphillian sites ($p < 0.01$) indicated drier and more open habitats on average in the Hemphillian than in the Barstovian. These results are consistent with previous phytolith studies and provide independent evidence for an increase in open, arid habitats co-occurring with the RICE. Besides its paleoecological implications, this study demonstrates that a multivariate approach to vertebrate ecometrics is viable. Future work will compare results from bivariate and

multivariate methods directly to determine which yield better models.

Funding Sources Geological Society of America
South Dakota School of Mines and Technology

Virtual Posters

A DESCRIPTION OF THE PALATE AND MANDIBLE OF *YOUNGINA CAPENSIS* (SAUROPSIDA, DIAPSIDA) AND THE PHYLOGENETIC IMPLICATIONS

Hunt, Annabel K.¹, Ford, David¹, Fernandez, Vincent², Benson, Roger¹

¹Earth Sciences, University of Oxford, Oxford, Oxfordshire, United Kingdom, ²Natural History Museum London, London, United Kingdom

The Late Permian reptile *Youngina capensis* (~254 Ma) is a non-saurian neodiapsid whose anatomy has been used to represent the reptilian condition prior to the divergence of Sauria (crown group reptiles). However, despite being first described over 100 years ago, the anatomy of *Youngina* remains incompletely documented. Here we use micro-computed tomography to document new features of the palate (including the parabasisphenoid) and mandible of *Youngina capensis* (BPI 2871). Some of our new observations include the identification of a dentate parasphenoid, an anteriorly bifurcating vomer and a strongly convex coronoid eminence. The former of which is particularly important given that the parasphenoid of *Youngina* was previously described as edentulous. Indeed, the presence of parasphenoidal teeth, a primitive reptilian trait, suggests that *Youngina* may represent a more stemward lineage among non-saurian neodiapsids. To test this hypothesis, we carried out a phylogenetic analysis using Bayesian inference and incorporating the new morphological data. Our results recover *Youngina* as an early diverging neodiapsid. We therefore posit that the complete lower temporal bar of *Youngina* likely represents the plesiomorphic neodiapsid condition, and that the loss of the lower temporal bar may have occurred relatively early in the neodiapsid lineage. Our new observations will benefit future studies on saurian origins by providing improved constraints on neodiapsid anatomy prior to the divergence of the reptilian crown-group.

Colbert Prize Session

ELUCIDATING THE ECOLOGICAL AND LIFE HISTORY DRIVERS OF AVIAN SKULL EVOLUTION USING HIGH DENSITY 3D GEOMETRIC MORPHOMETRICS

Hunt, Eloise S.¹, Felice, Ryan N.², Tobias, Joseph³, Field, Daniel J.⁴, Lautenschlager, Stephan⁵, Goswami, Anjali¹

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Darwin's finches are a famous example of evolution linking bird skull morphology with diet. Yet large-scale studies have called the strength of the correlation between diet and cranial anatomy into question. We tested the influence of habitat density, migration, and developmental mode on shaping avian skull evolution through deep time. We used a sample of high-density 3D geometric morphometric data for 354 species across all extant birds for phylogenetic regressions and estimated evolutionary rates. There is a significant relationship between shape and both habitat density and migration categories ($p < 0.001$), but not between shape and developmental mode ($p = 0.096$). We also compared evolutionary rates among ecological groups and recover faster rates of evolution in groups that occupy dense habitats, are migratory, and have precocial life histories. These patterns suggest that habitat density and migration help shape the tempo and mode of avian phenotypic evolution, and that drivers of avian skull shape evolution are not solely restricted to diet. However, these findings, and previous morphometric studies, have relied primarily on inferences from extant lineages, despite evidence that incorporating fossils improves ancestral state estimates and evolutionary model fitting. To bridge this gap in our understanding, we quantified patterns of 3D skull shape variation across extinct and extant Galloanserae (ducks, chickens, and relatives). Extant Galloanserae only represent a fraction of the remarkable morphological and ecological disparity they attained over ~67 million years of evolution, ranging from pseudotoothed pelagornithids to giant flightless gastornithids. We reconstructed the 3D morphology of eight fossil specimens, including *Asteriornis maastrichtensis* and *Pelagornis chilensis*, to incorporate them into a dataset of >200 extant Galloanserae species. Principal component analysis reveals that extinct clades greatly expand the breadth of morphospace occupation beyond what could be inferred from extant taxa alone. Preliminary results show significant relationships between Galloanserae skull shape and habitat density ($p = 0.002$), migration ($p = 0.016$), and ecology ($p = 0.039$). Together, these results demonstrate that cranial morphology across crown birds is shaped by complex interactions among ecological drivers and observations from the fossil record are essential for reconstructing patterns of anatomical evolution through time.

Funding Sources A NERC SSCP DTP studentship to ESEH ([NE/S007415/1]); with data collection funded by the Geologists' Association and Paleontological Society grants to ESEH.

OCCURRENCE OF THE PINEAL GLAND AND ARACHNOID MATER IN ALLIGATOR INDICATE AN ARACHNOID IN ALL TETRAPODS AND A PINEAL IN ALL VERTEBRATES, EXCEPTING MYXINI. CEREBROSPINAL FLUID OCCUPIES MOST OF THE BRAIN CAVITY VOLUME IN THE LARGEST ADULT ALLIGATOR

Hurlburt, Grant R.

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The contents of the brain cavities of non-avian archosaurs have been inadequately understood. Dissection of the brain and surrounding tissues of large specimens (ca. 80 kg) of *Alligator mississippiensis* indicates that extant crocodylians possess a pineal gland, an arachnoid mater, and a subarachnoid (SA) space containing cerebrospinal fluid (CSF). This has consequences for understanding the distribution of these characters within Tetrapoda and Vertebrata, and for inferring the morphology and size of neural and non-neural structures from endocranial casts of fossil non-avian archosaurs.

All extant members of Tetrapoda possess an arachnoid, and a SA space containing CSF, produced in the ventricles by choroid plexuses. All extant members of Vertebrata, including Petromyzontidae (lampreys), but excluding Myxini (hagfish), possess a pineal gland. The pineal gland of extant alligators does not leave an impression on the endocast; absence of similar impressions on endocasts of non-avian archosaurs does not preclude possession of a pineal gland. Application of the Extant Phylogenetic Bracket indicates that non-avian dinosaurians and other extinct nonavian reptilians, and probably all extinct tetrapods possessed an arachnoid and SA space containing CSF.

Branching channels on the external surface of the dura mater over the lateral cerebral hemispheres indicate the presence of a branching artery. Previously, evidence of similarly located dural arteries on hadrosaurid endocasts has been considered a reason that the brain:endocast volumetric relationships within extant crocodylians may not be applicable to non-avian dinosaurians.

The size of the CSF-filled SA cavity accounts for most of the discrepancy between brain volume and brain cavity volume in crocodylians, not the dorsal venous sinuses. The brain occupies as little as 33% of brain cavity volume in the largest alligators. The occipital sinus is a flattened, roughly C-shaped cavity within the dura mater, lying dorsal and lateral to the medulla oblongata. The external and internal walls of the occipital sinus are connected by trabeculae and short septa.

Large specimens of crocodylians display configurations of blood vessels and the SA space that do not occur in small specimens. This information can improve interpretation of endocasts of non-avian dinosaurians other than members of Maniraptoriformes.

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

A NEW TERRESTRIAL-DOMINATED MICROFOSSIL ASSEMBLAGE FROM THE LATE CRETACEOUS TWO MEDICINE FORMATION OF MONTANA, U.S.A.

Hutchinson, Ian S.¹, Brown, Isaac¹, Redman, Cory², Varricchio, David³, Moore, Jason¹

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In comparison to other temporally and spatially proximal units (e.g. the Hell Creek or Judith River Formations), the microfauna of the Two Medicine Formation is relatively sparsely known. Here we present the description of a new Late Campanian (~75 Ma) vertebrate microsite from the Willow Creek Anticline, collected in proximity to the famous Egg Mountain locality in western Montana. This provides a new window into the vertebrate palaeoecology of the Two Medicine Formation.

There were a total of 115 identifiable specimens recovered after processing approximately 3000 kg of siltstone matrix from the study site. Although this is a relatively low microvertebrate concentration, the recovery of fossils from unremarkable Two Medicine sediments suggests that similar high-effort sampling approaches elsewhere in the formation might provide an alternative avenue to gather palaeoecological samples. The assemblage has an unusually terrestrial aspect in comparison to other penecontemporaneous assemblages (88%), and is surprisingly diverse, with a minimum of 18 identifiable taxa. Seventy-five of the specimens were of dinosaurs including hadrosaurids (15), small ornithopods (1), ankylosaurids (10), dromaeosaurs (6), troodontids (5), birds (3), and tyrannosaurids (15). Theropod teeth (42%) dominated the dinosaurian component of the assemblage, likely due to the rapid replacement of theropod teeth throughout the lifetime of the individual leading to their overrepresentation. The non-dinosaurian portion of the assemblage included mammals (23), amphibians (11), fish (3), and other reptiles (4). A single albanerpetontid vertebra marks the first record of an albanerpetontid amphibian known from the Two Medicine Formation.

Technical Session 11: Synapsida (Friday, November 4, 2022, 8:00 AM)

NEW BAURIAMORPH RECORDS FROM THE EARLY TRIASSIC OF SOUTHERN PANGAEA TEST THE PRINCIPLE OF GEOGRAPHIC EXCLUSION IN THE GLOBAL RADIATION OF BAURIIDS AND CYNODONTS (SYNAPSIDA)

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Bauriamorphs were a subclade of Triassic therocephalians (Baurioidea) that shared many characteristics with cynodonts, including a complete secondary bony palate and complex, molar-like teeth. Restudy of late Early (Olenekian) to Middle Triassic (Anisian) baurioid therocephalians from China and new records from the Karoo and Beacon basins of southern Pangea permit a geographic and phylogenetic history of the clade to be reconstructed.

In the Lower Triassic Katberg Formation (Karoo Basin, South Africa), small baurioid therocephalians and cynodonts (~5–10 cm skull length) make up approximately equal proportions of identified vertebrate specimens (~17–18% each; 35% total). During 2017–2018, collecting in the Karoo Basin and Antarctic Beacon Basin produced noteworthy baurioid specimens. A large specimen from the Katberg Formation referable to the baurioid *Scalopsaurus* (11 cm skull length; 84% larger than the previous largest known specimen) reveals distinctive subadult morphology in a genus based previously on juveniles, and supports its position as the sister taxon to the Triassic Bauriamorpha. The new specimen contributes a revised differential diagnosis of the genus, minimizing reliance on size-related and juvenile traits.

Restudy of Chinese specimens housed at the Institute of Vertebrate Paleontology and Paleoanthropology—the ‘ordosiids’ *Hazhenia* and *Ordosiodon*—by us in 2018 coincided with the discovery of a new specimen of bauriamorph from the middle Fremouw Formation (upper Lower Triassic) of Antarctica, bridging the morphology of earlier baurioids and the anatomically derived bauriids. A cladistic analysis of 58 therapsid and 137 morphological characters resolves the Antarctic taxon as the sister to *Nothogomphodon*, ‘ordosiids,’ and Bauriidae (which are well represented in northern Pangea). We conclude that ‘transitional’ bauriamorphs were rare in the southern hemisphere during the Triassic, a phenomenon owed to one of two hypotheses: (i) there is a hiatus in the Karoo fossil record (e.g., within the upper Katberg or at the Katberg-Burgersdorp transition); or (ii) there was no hiatus, but their local scarcity during Olenekian times was hindered by coeval cynodont competitors.

Funding Sources CAS was funded by NSF ANT-1341304

Technical Session 9: Mammals (Friday, November 4, 2022, 8:00 AM)

BRIDGING WILDLIFE CRIME WITH FOSSIL CRIME: THE CONNECTION BETWEEN MAMMOTHS AND BLOOD IVORY

Huynh, Andy

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The demand for ivory in Asia resulted in mass-poaching of African elephants and is the driver of their impending extinction. Ivory products are sought for traditional medicine and as status symbols. In 2017, China closed its ivory carving facilities due to global pressure. Unfortunately, the shutdown fueled the illegal ivory trade. Because extant ivory stock in the black market is decreasing, mammoth ivory is exploited to satisfy the demand.

Russian organized crime coerces indigenous groups in Siberia to collect the ivory from permafrost. The increase in arctic temperatures due to climate change has accelerated the melting of permafrost, exposing Neogene fossils locked within it. Criminals and locals use high-pressure water hoses to reach mammoth tusks, and then leave the rest of the skeleton to the elements. Small articulated skeletons of other species are blasted away. This results in the loss of data on mammoths and the fossil fauna of the Lena and Yana River deltas. Organized crime trafficks ivory and other illicit goods with ease through Mongolia between Russia and China, due to a lack of effective enforcement. Eurasian crime organizations also use the same strategy to traffick extinct rhino horn (*Coelodonta antiquitatis*).

A United Nations Office on Drug and Crime (UNODC) investigation into illegal Asian wet markets in 2018 and 2019 found three times more mammoth ivory than extant ivory. In 2019 UNODC found that 13 mammoth tusks were sold for \$35,000 USD each and, in 2021, 29 tons of mammoth ivory was exported to China. In 2018, UNODC investigated a bill of lading in Chinese ports that trafficked 16 mammoth tusks. In a 2019 seizure, UNODC discovered 12 mammoth tusks in elephant ivory stock in Mongolia. The sum of poached specimens since 1990 (from the separate investigations of WildLeaks, TRAFFIC, UNODC, and the International Criminal Police Organization) is at least 1,000.

Although the precise amount of mammoth ivory - and skeletons - lost to science is unknown, the global criminal network is increasingly proficient at monetizing the fossils. There are currently no legal regulations to limit the harvest and global trade of mammoth ivory. With the continued decrease of living *Loxodonta* populations and climate change, mammoth ivory harvest will increase unabated.

Technical Session 5: Amphibians & Early Reptiles (Thursday, November 3, 2022, 8:00 AM)

NEW ANATOMICAL DATA OF THE ENIGMATIC CARBONIFEROUS TETRAPOD *WESTLOTHIANA* *LIZZAE* FROM SYNCHOTRON PHASE-CONTRAST

CT REVEALS RETENTION OF PRIMITIVE CHARACTERS CLOSE TO THE AMNIOTE CROWN

Igielman, Ben, Benson, Roger

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The Visean tetrapod *Westlothiana lizae*, from East Kirkton, Scotland, was initially described as a “reptiliomorph”, close to crown amniotes. However, anatomical data are incomplete because most bones are embedded in matrix, and phylogenetic analyses have yielded inconsistent results. *Westlothiana* has been recovered separately as a sister taxon to amniotes, to lepospondyls, or to a lepospondyl-amniote clade. We report considerable new anatomical data, including the near-cranial anatomy based on synchrotron phase-contrast computed tomography (CT). This reveals a mosaic of traits shared with crown Amniotes, with deeper stem tetrapods such as seymouriamorphs, and with microsaur, a tetrapod clade themselves of uncertain affinity. Characters of the vertebrae, the foot, and the loss of the intertemporal from the temporal region indicate a close relationship with amniotes. However, the palatal dentition is revealed in detail for the first time, and shows a strikingly extensive shagreen of denticles, as well as fang pairs on the palatines and vomers, reminiscent of deeper stem tetrapod clades such as seymouriamorphs and gephyrostegids. *Westlothiana* also shows to have a distinctly microsauro-like large tabular. Phylogenetic analysis recovers *Westlothiana* as the sister taxon to the well supported amniote - diadectamorph clade. This suggests the retention of a large tabular and primitive palatal dentition, including palatal fangs, closer to crown amniotes than has been previously hypothesised. The advanced age of *Westlothiana* also indicates that many of the key divergences along the amniote stem had occurred by the Early Carboniferous.

Funding Sources This project is funded by the Oxford NERC DTP

Virtual Posters

A PRELIMINARY REPORT OF ALBANERPETONTID AMPHIBIANS (AMPHIBIA: ALBANERPETONTIDAE) FROM THE LOWER CRETACEOUS OHYAMASHIMO FORMATION OF THE SASAYAMA GROUP, HYOGO, JAPAN

Ikeda, Tadahiro, Ota, Hidetoshi, Tanaka, Tomonori

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A vertebrate fossil assemblage consisting of eggshell fragments of theropod dinosaurs and skeletal elements of anurans and lizards has been reported from the Kamitaki Egg Quarry of the Ohyamashimo Formation, Sasayama Group at Kamitaki, Tamba City, Hyogo Prefecture, Japan. Recently, the quarry yielded additional specimens of microvertebrates, of

which one dentary, one parietal, and one frontal have been assigned to an enigmatic amphibian group, Albanerpetontidae, on the basis of features unique to the group, such as a complex 'mortise and tenon' interdentary joint, non-pedicellate and slightly tricuspid teeth, and a sculptured and fused frontal. These three fossil elements are collectively referred to as "the Tamba specimen" below, under the assumption of their being from the same individual because of their proximity with each other in the same sediment.

Quite a few fossils representing albanerpetontids have been described from the Jurassic to the Neogene deposits of Europe and North America. In East Asia, however, fossils belonging to this group of amphibians are quite rare: only recently, albanerpetontids were reported from the region on the basis of a few specimens found from the Lower Cretaceous Kuwajima Formation, Tetori Group, Japan, and described as *Shirepeton isajii*. We have compared the Tamba specimen with *Shirepeton*, as well as with *Yaksha* from the Upper Cretaceous amber in Myanmar, and known albanerpetontid taxa from Europa and North America (i.e., *Anoualerpeton*, *Celtedens*, *Wesserpeton*, and *Albanerpeton*). The Tamba specimen differs from known taxa in the shapes of the subdental shelf of the dentary, the internasal and anterolateral processes of the frontal, and the postorbital wing of the parietal. A preliminary phylogenetic analysis using the character matrix integrating the previous and the present observations suggests that the Tamba specimen is located basal to the branch consisting of *Shirepeton*, *Yaksha*, *Al. nexuosum*, and Cenozonic albanerpetontids (i.e., *Al. pannonicum*, *Al. inexpectatum*, and the unnamed Paskapoo sp.). It is therefore highly likely that the Tamba specimen represents an undescribed taxon of Albanerpetontidae, though further detailed investigations are yet needed to strengthen such view and describe the Tamba specimen appropriately. Results of our study will contribute to our better understandings on the diversity and biogeography of the Mesozoic microvertebrates in East Asia.

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

DIFFERENT PROTEIN RECOVERY RATE IN FOSSIL BONE AND DENTINE SAMPLES: IMPLICATIONS FOR THE APPLICATION OF PALEOPROTEOMIC METHODS IN PALEONTOLOGICAL STUDIES

Inaba, Hayato¹, Chiba, Kentaro², Saneyoshi, Mototaka², Miyaji, Takaaki³, Kawakami, Asako³, Takechi, Yasushi⁴, Brink, Kirstin⁵, Tsujigiwa, Hidetsugu⁶

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Recently paleoproteomics, the study of ancient proteins recovered from archaeological and paleontological samples, has been radically developed. Paleoproteomic studies usually use type 1 collagen (COL1), the predominant protein in bones and teeth (dentine) of vertebrates. In this study, we evaluate the protein recovery rate from these two different tissues to foster the applications of this method to a broader range of paleontological specimens. We sampled Pleistocene elephantid specimens recovered in the Bisan Seto area, Japan: one rib, one ulna, and three incisors. To evaluate protein preservation in the samples, we used total protein and collagen colorimetry, electrophoresis (SDS-PAGE), and MALDI-TOF mass spectrometry for amino acid sequence determination of the sampled protein. SDS-PAGE on the rib and ulna showed two distinct bands under 37 kilodaltons, which were not observed on incisor samples and the negative control. The determined amino acid sequences of the bone samples based on mass spectrometry were identical to that of COL1 peptides of *Mammot americanum*, the only elephantid COL1 sequence in the protein sequence database that we used. The colorimetric analysis quantified the total protein and collagen extracted from the bones (128 – 168 and 12.7 – 14.1 mg/g) and the incisors (0.00 – 1.32 and 0.00 – 0.79).

The results of SDS-PAGE and mass spectrometry indicate that we are successfully recovering endogenous fossil proteins from bone samples. The result of the colorimetric analysis demonstrates that the protein recovery rate is significantly better in the bone samples than in the dentine samples. This pattern can be explained by the difference in microscopic structures between bones and dentine; numerous and consistently arranged dentine tubules in teeth facilitate the loss of proteins during diagenesis. Studies of protein extraction from fossil elephantid samples often use incisors, but this study suggests that the use of bone instead of teeth would improve the extraction result of fossil proteins. This will greatly expand the breadth of samples available for future analyses, including, for example, bonebed material represented by fragmentary bones and edentulous taxa.

Funding Sources JSPS KAKENHI Grant Number 20K20950; Promotion of Okayama University of Science (OUS) Research Project (OUS-RP-22-5)

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

MAMMALIAN DISTAL HUMERI FROM THE BUG CREEK ANTHILLS, MONTANA

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The Bug Creek Anthills (BCA) is a locality in northeastern Montana that contains time-averaged Late Cretaceous (Lancian) and early Paleocene (early Puercan [Pu1]) fossils that pre- and post-date the Cretaceous-Paleogene (K-Pg) mass extinction event. These fossils are abundant and include well-preserved mammalian postcranial remains, which exhibit considerable morphological diversity. These factors may make it possible to use this assemblage to identify, associate, and attribute postcranial elements to taxa previously known at BCA only from teeth. In an initial assessment of skeletal diversity at this site, we analyzed the distal humeral morphology of the multituberculate and eutherian mammals from BCA. The distal humerus is a functionally important region of the postcranium: the trochlea and capitulum articulate with the ulna and radius at the elbow joint, and the medial epicondyle is the site of origin for the wrist and digital flexor muscles. Previous studies have demonstrated that these features relate to the degree of elbow mobility and grasping capability, making the distal humerus useful in inferring substrate preference. We qualitatively assessed 45 BCA distal humeri and assigned each specimen to morphological groups designated in a previous study of mammalian humeri across the K-Pg boundary in Montana. We micro-CT scanned these fossils to generate 3-D models of each specimen, and, depending on preservation, we took up to eight linear measurements on each one. We conducted principal components and linear discriminant analyses on these variables to compare groups in morphospace. We identified three groups of eutherians and four groups of multituberculates in our BCA sample. These two clades are distinct in their distal humeral morphology, and they plot separately in morphospace. Compared to the multituberculates, the eutherians have a mediolaterally wider medial epicondyle and capitulum and a proximodistally shorter trochlea. There is also considerable size variation among groups in both clades, illustrating another aspect of postcranial diversity. Two multituberculate groups designated in the previous study of K-Pg mammalian humeri overlap in morphospace, suggesting that these groups are not distinct in their morphology and overlap in size. This analysis is the first step in our broader study of other well-preserved postcranial elements from BCA, which will allow us to better understand taxonomic, body size, and locomotor diversity at this site.

Funding Sources Yale Peabody Museum of Natural History Division of Vertebrate Paleontology, National Science Foundation DEB 1456826, PSC CUNY Award

Virtual Posters

LOWER CRETACEOUS SPINOSAURID REMAINS OF LA RIOJA (SPAIN): PRELIMINARY RESULTS OF THE CAMEROS PARTIAL SKELETON

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The Cameros Basin is one of the most important Iberian basins for the study of Early Cretaceous European dinosaur faunas and associated biota. Among the theropod sample, allosauroids, baryonychines, carcharodontosaurids, dromaeosaurids, as well as indeterminate coelurosaurians and theropods have been identified up to date. While theropods are more diverse in the Western Cameros formations, spinosaurids are by far the predominant group in the eastern part of the Cameros Basin.

The Eastern Cameros spinosaurids come from the uppermost Barremian-lower Aptian deposits of the Enciso Group of Igea (La Rioja, Spain), which has been interpreted to be formed in a palustrine-lacustrine environment. The spinosaurid fossils consist of several isolated teeth, a partial left maxilla, and two more complete and partially articulated specimens. The first of them mainly preserves parts of the pelvic girdle and hindlimbs, and the second one axial and pelvic elements.

Another theropod individual has been recovered from the Enciso Group, which is the most complete and it is partially articulated, being represented by cranial, axial and appendicular bones. Based on previous published phylogenies, the megalosauroid synapomorphies in this specimen are: (1) the rounded medial epicondyle of the femur, and (2) the shallow medial fossa of the fibula. Furthermore, the dorsal vertebrae of this specimen show accessory centrodiapophyseal laminae, recovered as a spinosaurid or a baryonychine synapomorphy depending of the study.

Therefore, based on these features, this new material from Eastern Cameros Basin is interpreted as another specimen of spinosaurid, which most likely belongs to Baryonychinae. This specimen further supports the dominance of this theropod group in the Lower Cretaceous palustrine-lacustrine ecosystems of Eastern Cameros Basin. The sum of all spinosaurid remains found in Igea, and in particular this last specimen would help determine a more accurate phylogenetic position of this individual within Spinosauridae.

Funding Sources Spanish Ministry-ERDF (CGL2017-85038-P) and the Basque Government (IT1418-19; PRE_2019_1_0215)

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

**A NEW SPECIES OF *CYPRIPEDIODENS*
(CHONDRICHTHYES, PETALODONTOFORMES,
JANASSIDAE) FROM THE LATE MISSISSIPPIAN OF
ALABAMA, USA**

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The Late Mississippian Bangor Limestone of northern Alabama preserves a diverse assemblage of chondrichthyan remains, including teeth, tooth plates, and finspines. This assemblage is poorly studied compared to some others of similar age in North America. Teeth recently recovered from the Bangor Limestone of Franklin County, Alabama, USA, appear to represent a new species of *Cypripedioidens*. The genus was previously known only from the Eyam Limestone Formation (Mississippian, late Viséan) of Derbyshire, England. The Alabama bed has been dated by conodont and echinoderm biostratigraphy to the Hombergian regional substage of the Chesterian regional stage (Mississippian, early Serpukhovian), which is younger than the Derbyshire bed. *Cypripedioidens cristatus*, the type and only previously known species of *Cypripedioidens*, is distinguished by possessing a labiolingually elongate crown, a central trough that is concave in lateral view, a labial cusp with a nearly circular cross-section, a lingual cusp, and several cristae on the lingual heel. The new species resembles *C. cristatus* but differs in lacking the lingual cusp and has a more labiolingually compressed labial cusp. Nonetheless, it is sufficiently similar to *C. cristatus* and sufficiently different from all other janassid petalodonts that it is assigned to *Cypripedioidens*.

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

**INTERLOCKING MECHANISMS OF CROCODYLIAN
HINDLIMB JOINTS USING A PASSIVE
MUSCULOTENDINOUS STRUCTURE DURING THE
HIGH WALK**

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Terrestrial vertebrates have interlocking mechanisms of limb joints by the coordination of passive musculoskeletal structures, enabling effective locomotion and weight support. These structures have long been studied, especially in some animals like horses, but have also been applied to robotics to replicate the efficient and 'natural' locomotion of animals. Understanding these passive structures must be crucial to the comprehensive elucidation of extinct animals' biomechanics but has not generally been accounted for in paleontological studies, partially due to the difficulties of simulating these

passive structures in silico. In this study, we aim to identify passive structures in the musculoskeletal system of the crocodylian hindlimbs and validate its mechanism using a physical model to better understand archosaur locomotion and its evolutionary history.

The observation of crocodylian locomotion and the dissection of *Crocodylus porosus* hindlimbs suggests that a passive structure is effective in the stance phase during high walking. The passive structure locks the knee and ankle joints by combining the tension of the caudofemoralis longus, gastrocnemius, and flexor digitorum muscles with associated tendons and the ground reaction force, enabling the support of weight. This structure is supposed to be an analogue to the stay apparatus in horse hindlimbs. Subsequently, we created a physical model using 3D printed pelvic and hindlimb bones from the CT scan of the dissected individual, strings imitating the muscles and tendons, and a motor mimicking contraction of the caudofemoralis longus muscle. The experiment using the physical model demonstrates that the robot supports the weight and keeps a standing posture by only pulling the string imitating the caudofemoralis muscle while the pes is in contact with the ground.

Together with the results of this study, the inferred similar musculoskeletal system between extant crocodylians and non-avian dinosaurs implies that the non-avian dinosaurs would have had a similar passive structure. Further investigation of these passive musculoskeletal structures in extant archosaurs, including birds, would provide us with an intriguing avenue to understand macroevolutionary patterns in archosaur locomotion and musculoskeletal systems.

Funding Sources JST Support for Pioneering Research Initiated by the Next Generation J219713007, JST MOONSHOT JPMJMS2032, KAKENHI 20K04390, Grant for Promotion of OUS Research Projects

Symposium: A Late Miocene Shangri-la (Wednesday, November 2, 2022, 1:45 PM)

**SHUITANGBA PRESENTS A REMARKABLE
SNAPSHOT OF LATE MIOCENE VERTEBRATE
EVOLUTION IN EAST ASIA**

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Shuitangba is located in one of many sedimentary basins in southwestern China that formed during the late Paleogene to late Neogene and that preserve significant fossil records of terrestrial biotic diversity and ecosystem change. The basins of Yunnan Province were exceptional “laboratories” of biotic evolution and community formation because they differed in their geological origin, geometries and physical orientation, latitude, annual rainfall and solar regimes, and degree of physical isolation with respect to the habits of volant and non-volant vertebrates. Shuitangba, in the Zhaotong Basin, is a particularly noteworthy site because the excellent preservation of vertebrate and plant megafossil remains there provides a relatively complete snapshot of biotic diversity over a short timespan in the latest Miocene. For students of the “late Miocene faunal turnover,” Shuitangba illustrates how variable and contingent the turnover was, even with respect to nearly contemporaneous sites. Differences in vertebrate species composition between Shuitangba and Lufeng, in particular, were probably driven by multiple factors, including the nature of the environments, habitat diversity, geographical isolation, and taphonomic circumstances of the two sites in their respective basins. Differences in the spatial configuration of the basin landscapes influenced the dispersal of small mammals, including primates, into and out of the basins and thus played a role in determining the community composition. Powerful regional factors such as tectonism related to the elevation and outward expansion of the Tibetan Plateau and changes in seasonal rainfall regime caused by intensification of the Indian monsoon, affected all of Yunnan’s basins in the late Miocene, but these were mitigated or intensified by the spatial configuration and habitat diversity of individual basins. These phenomena probably account for Zhaotong and other latest Miocene regional basins being refugia for some mammalian taxa that had become extinct elsewhere, such as the hominoid primate *Lufengpithecus*, and a possible center of origin for others such as the proboscidean, *Stegodon zhaotongensis*.

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Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

GEOMETRIC MORPHOMETRICS OF SNAKE TRUNK VERTEBRAE INDICATE ECOMORPHOLOGICAL TRENDS, PHYLOGENETIC SIGNAL, AND CONVERGENCE ACROSS TAXONOMIC GROUPS

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Snakes are among the most specialized vertebrates in history. Skeletal specializations in the elongate, limbless body form of snakes has resulted in incredible locomotive adaptability (including at least, but oft-overlooked vertebral complexity). As such, understanding variation in both living and fossil snake vertebral morphology is useful for research in taxonomy, ecology, phylogeny, evolution, and even robotics. Here, we use 23 landmarks to evaluate shape variation in 504 snake trunk vertebrae representing 11 families, 16 subfamilies, 89 genera, and 189 species to assess the use of vertebral shape for taxonomical delimitation and primary foraging habitat assignment. We extracted shape scores and ordinated landmarks using Generalized Procrustes Superimposition and Principal Component Analysis for three groups of data: the full dataset, a North American group, and a Crotalinae-only group. We found that snake vertebral shape associated with articular surfaces and overall proportions contained both phylogenetic and ecomorphological signal, as indicated by analyses of variance for all groups and a phylogenetic generalized least squares analysis of the North American group. Furthermore, differences in primary foraging habitat resulted in similar morphological trends within groups in shape space.

Discriminant Function Analysis of the full dataset had high overall accuracy for family (96%) and subfamily (86%), but only moderate success for genus (68%), species (58%), and primary foraging habitat (57%). Within a single subfamily, however, overall accuracy greatly increased for genus (82%) and primary foraging habitat (90%), while accuracy for species (63%) showed less improvement, perhaps because of less variation and lower sample sizes for each individual species. Geometric morphometrics can be a valuable tool for both taxonomic delimitation and ecological assignment alongside qualitative descriptions, particularly when quantitative methods are applied at multiple levels. Future work should focus on increasing sample sizes for poorly sampled groups for a more complete understanding of ecomorphological and phylogenetic signal in snake vertebral shape.

Technical Session 1: Dinosaurs (Wednesday, November 2, 2022, 8:00 AM)

CRANIAL DESCRIPTION OF A NEW BASAL SAUROPODOMORPH FROM THE EARLY JURASSIC OF ANTARCTICA

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Basal sauropodomorphs are a paraphyletic clade of animals that make up the precursors to true sauropods. These non-sauropod sauropodomorphs arose during the Late Triassic and diversified throughout the Early Jurassic until their extinction at the Early/Middle Jurassic boundary. Basal

sauropodomorphs achieved a global distribution during their reign, including ranging into high latitudes. We describe the cranial anatomy of a new species of basal sauropodomorph from the Early Jurassic of Antarctica. This new specimen, FMNH PR 3051, is a juvenile and was collected from the lower Hanson Formation on Mt. Kirkpatrick and represents the only cranial remains of a sauropodomorph from that continent. Only one other basal sauropodomorph, *Glacialisaurus hammeri*, is currently described from Antarctica, but differs from FMNH PR 3051 in femoral anatomy. The skull is mostly complete apart from missing the parietals, one frontal, supraoccipital, and orbitosphenoids, but is mediolaterally compressed and sheared obliquely. We used μ CT scans to create a digital model of each preserved skull bone in three dimensions. An autapomorphy of FMNH PR 3051 is having unserrated teeth, unlike other basal sauropodomorphs. The distal margin of the teeth near the apical end are recurved so that the distal margin is concave rather than straight. The teeth are concave along the lingual margins and bear longitudinal labial grooves. The ratio of the anteroposterior length of the naris to the orbit is smaller relative to other basal sauropodomorphs. The dentary is dorsoventrally expanded near the symphyseal region. FMNH PR3051 is distinguished from other massospondylids by a larger humerus to femur length ratio and a smaller humerus width to length ratio though these may be ontogenetically variable traits. The preacetabular process extends anteriorly past the pubic peduncle unlike in most other basal sauropodomorphs. Phylogenetic analysis suggest that FMNH PR 3051 is a massospondylid. It forms a clade with *Ignavusaurus* and *Saraksaurus* from South Africa and North America, respectively, with FMNH PR 3051 being sister to *Saraksaurus*. *Glacialisaurus*, while also a massospondylid, is more closely related to South American and South African species. We will use these phylogenetic results to examine the biogeographical implications of this new taxon and improve our understanding of the distribution of basal sauropodomorphs throughout Gondwana during the Early Jurassic.

Funding Sources Jurassic Foundation; Paleontological Society Student Research Grant

Technical Session 13: Early Archosaurs & Pterosaurs (Friday, November 4, 2022, 1:45 PM)

THE REPTILIAN AVIATION PIONEERS: NEW MIDDLE JURASSIC FOSSILS UNCOVER THE UNSEEN DIVERSITY OF NON-PTERODACTYLOID PTEROSAURS

Jagielska, Natalia¹, Brusatte, Stephen L.¹, O'Sullivan, Michael², Butler, Ian¹, Challands, Tom¹, Clark, Neil⁶, Fraser, Nicholas C.³, Penny, Amelia⁴, Ross, Dugald⁵, Wilkinson, Mark¹, Funston, Gregory¹

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Non-pterodactyloid pterosaurs were a grade of Mesozoic reptiles and the first vertebrates to achieve active flight. They are characterised by an elongate tail; short cervical vertebrae and a curved fifth pedal digit. The Jurassic saw non-pterodactyloids become a dominant, cosmopolitan volant clade, but we know little about the dynamics of their evolution. The record starts in the Late Triassic, and is then well represented in a series of lagerstätten in the Early and Late Jurassic. However, the Middle Jurassic, a time of probable diversification of the clade, represents a significant gap in the record.

British Middle Jurassic deposits offer a rare glimpse into that elusive period. For a time, the Middle Jurassic pterosaurs were known only from fragmentary undiagnostic specimens. The recent discovery of a well-preserved pterosaur from the Scottish Bathonian Lealt Shale, *Dearc sgiathanach*, helps contextualize these fragmentary fossils, which have undergone a comprehensive review, contextualised by the rigorous description of new material. To survey the diversity and body sizes of Middle Jurassic pterosaurs, we used scaling equations to estimate wingspans from isolated bones and a new phylogenetic analysis of 58 taxa scored for 158 characters. This placed the most complete specimens on the new family tree and discovered previously overlooked trends in diversity and body size. We thoroughly describe the anatomy of *Dearc* and provide evidence that it was a large-bodied (>2.5-meter wingspan) non-pterodactyloid. Understanding the anatomy of *Dearc* helped us identify new elements from Skye belonging to a non-pterodactyloid with a comparably large wingspan, composed of a three-dimensionally preserved hindlimb and tail.

Our study indicates that non-pterodactyloids were larger than previously suspected and, despite occupying a range of environments, conformed to a standardised body plan with little alteration from that of *Dorygnathus* in the Early Jurassic. The first substantial material from the Middle Jurassic demonstrates that the non-pterodactyloid clade almost reached its zenith of diversity during this interval—subsequently remaining almost unchanged until the Late Jurassic. This observation has implications for preservational biases: non-pterodactyloids may have lived in aquatic habitats, favouring preservation, compared to pterodactyloids, which must have been present in the Middle Jurassic based on ghost ranges but whose fossils are rare.

Funding Sources The field trip and excavation were funded by the National Geographic Society (GEFNE185-16); this work was supported by a NERC DTP grant (NE/S007407/1).

Technical Session 17: Fish (Saturday, November 5, 2022, 8:00 AM)

RECONCILING GENETICS AND MORPHOLOGY: A REVISED PHYLOGENETIC ANALYSIS OF THE ENIGMATIC ELASMOBRANCH *PROTOSPINAX ANNECTANS* FROM THE LATE JURASSIC LAGERSTÄTTE OF SOLNHOFEN, GERMANY

Jambura, Patrick L.¹, Villalobos-Segura, Eduardo¹, Türtscher, Julia¹, Klug, Stefanie², Maisey, John G.³, Naylor, Gavin¹, Staggl, Manuel A.¹, Stumpf, Sebastian¹, Kriwet, Jürgen¹

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Since its original description in the early 20th century, the phylogenetic position of the Late Jurassic elasmobranch *Protospinax annectans* has been heavily debated and it was suggested that this fossil fish represented either a stem group batoid (rays and skates), a stem group elasmobranch (sharks, skates, and rays), a crown group batoid, a stem group squalomorph shark, a crown group galeomorph shark, or could represent the link between squalomorph sharks and batoids. Morphological studies using modern cladistic analyses resolved *Protospinax* as a very derived squalomorph shark and sister-group to the superorder Hypnosqualea, a clade comprising batoids, saw sharks, and angel sharks. However, recent molecular analyses reject the Hypnosqualea hypothesis and support a sister group relationship between sharks and rays. Although the phylogenetic position of *Protospinax* within this sister group hypothesis remains unclear, this extinct species still is used as a key taxon to calibrate molecular trees and, therefore, for making inferences about the evolutionary history of elasmobranch fishes.

Here we present a new, extraordinarily preserved holomorphic specimen from the Tithonian (Late Jurassic) Plattenkalk of Solnhofen (Germany) and reexamine the morphology and phylogenetic interrelationship of *Protospinax annectans*, based on a newly synthesized morphological data matrix. The resulting phylogenetic tree is in agreement with molecular phylogenies and resolves batoids as the sister group of modern sharks (Squalomorphii + Galeomorphii). *Protospinax annectans* is nested within the squalomorph sharks next to the squaliform shark, *Squalus acanthias*. Furthermore we applied a linear discriminant analysis on the log-transformed precaudal length and pectoral fin span of more than 50 living elasmobranch species representing eight specialized ecomorphotypes and *Protospinax annectans*. The results show a strong overlap of *Protospinax* with squatinobenthic and rhinobenthic elasmobranchs. Together with its crushing-type dentition, our analysis indicates that *Protospinax* was occupying a closely related niche to Jurassic and extant guitarfishes.

Funding Sources This research was funded in whole by the Austrian Science Fund (FWF) P33820.

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

LIMB PROPORTIONS IN HOPPING MAMMALS AND THE LOCOMOTION OF ARGYROLAGIDS

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Hopping mammals have evolved independently at least five times: in four families of rodents – Dipodidae (including jerboas), Heteromyidae (kangaroo rats), Muridae (Australian hopping mice), and Pedetidae (springhares) – all representing independent instances of hopping; and two families of macropodoids – Potoroidae (rat-kangaroos) and Macropodidae (kangaroos and wallabies) – likely sharing a hopping ancestry. Hopping mammals all have relatively long hind limbs and short forelimbs. Hoppers fall into two size categories: below 500 g (most rodents) and 1-70 kg (pedetids and macropodoids), possibly reflecting different evolutionary reasons for hopping (predator avoidance by jumping in the smaller forms, versus locomotor efficiency in the larger ones). Only macropodids exceed 3 kg, the size at which elastic energy storage in the leg tendons becomes feasible. The different hoppers show different proportions of their hind limb elements (femur, tibia, longest metatarsal and its proximal phalanx), as expressed as percentages of total limb length. A PCA of limb proportions shows relationship with both phylogeny and body size. Taxa rank along PC1 primarily by size: larger hoppers have relatively longer femora and smaller ones have relatively longer metatarsals, although dipodids are peculiar in having exceptionally long metatarsals. PC2 distinguishes forms with relatively longer proximal phalanges (dipodids and potoroids) from those with relatively longer tibiae (larger macropodids). Hopping may have evolved in one other instance, in the Argentinian Argyrolagidae (Marsupialia), which also have long hind limbs and short forelimbs. The overall limb proportions of the Plio-Pleistocene *Argyrolagus* (~137 g) cluster it with the hopping mice in the PCA, but in terms of metatarsal length it is more similar to dipodids. A bivariate plot of metatarsal length versus body mass shows hopping dipodids to have extremely long metatarsals relative to other small hopping rodents, and the argyrolagids *Argyrolagus* and *Microtragulus* cluster with them. We conclude that argyrolagids were not only likely hoppers, but in particular were like the highly specialized dipodids (jerboas) among extant hoppers.

Technical Session 3: Marine Reptiles (Wednesday, November 2, 2022, 8:00 AM)

A TWIST IN THE TAIL: RECONSTRUCTING UNDULATORY SWIMMING IN THE FIRST SECONDARILY AQUATIC AMNIOTE

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Secondary adaptation to life in water represents one of the most striking cases of convergence in the evolutionary history of tetrapods. This land-to-water transition has brought these unique animals to acquire a series of analogous adaptations to locomotion in water. Amongst all, the mesosaur *Mesosaurus tenuidens* was the earliest terrestrial tetrapod to have shifted to a fully aquatic lifestyle. Yet, debates regarding its locomotory abilities are still ongoing and currently lack robust biomechanical testing. Here, we developed a novel combination of range of motion analysis and mathematical sinusoidal wave model to quantify the undulatory swimming capabilities of the mesosaur body axis, along with movements of their limbs. In parallel, we applied our model to the marine iguana *Amblyrhynchus cristatus* to validate our analysis on extant taxa and compare our results with one proposed living morphofunctional analogue of mesosaurs. We find that the vertebral column of *M. tenuidens* was remarkably flexible in each 3D-plane, particularly significant in the caudal region, allowing for a wide range of lateral undulatory swimming modes. This flexibility would have enabled mesosaurs to generate sufficient propulsive thrust to adopt a body-tail driven swimming locomotion. Based on similar swimming modes observed in our model analogue *A. cristatus*, we propose that mesosaurs likely used vertebral undulation as their main mode of locomotion when completely submerged. Additionally, our results show that both fore- and hindlimbs retained some degree of movements. We therefore suggest that this non-mutually exclusive aptitude allowed mesosaurs to simultaneously employ their limbs as secondary means of propulsion (an idea corroborated by their webbed autopodia) and/or balance mechanism, particularly at lower degrees of undulation.

Funding Sources Innovation Fund of the Museum für Naturkunde – Leibniz Institute for Evolution and Biodiversity Research

Technical Session 5: Amphibians & Early Reptiles (Thursday, November 3, 2022, 8:00 AM)

VISUALIZING AN ELUSIVE HOLOTYPE: THE CRANIAL OSTEOLOGY OF *BOLOSaurus MAJOR* (PARAREPTILIA: BOLOSaurIDAE)

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Bolosaurus, a basal clade of parareptiles, are known for a unique combination of traits that are particularly novel during their evolution in the Early Permian. This includes facultative bipedality, a secondary palate, temporal fenestration, and distinctive heterodont dentition indicative of high-fiber herbivory. Despite pinpointing these features on different species of bolosaurs, we know little about the anatomy of Bolosauridae. This is because most recognized specimens are limited to dentition and portions of the marginal bones. Furthermore (and problematically), some holotype material of *Bolosaurus* has never been figured or illustrated, limiting our understanding of their anatomy and the evolution of the basal branches of Parareptilia. To address this, we CT scanned and segmented the holotype skull of *Bolosaurus major* Broom 1913 (AMNH 4461). While this specimen has never been figured in previous publications, it was previously described and compared to the first named species, *Bolosaurus striatus*. We confirm the presence of a secondary palate in *B. major*, previously only recognized in *Belebey vegrandis*, illustrating that this trait was present across Bolosauridae. *B. major* also demonstrates a dorsoventrally expanded coronoid that nearly spans the height of the lower jaw, indicative of large amounts of oral processing, consistent with a high-fiber diet. Finally, we show that among Early Permian taxa, *B. major* possesses an enlarged parietal foramen, suggesting that it and perhaps other bolosaurs were diurnal.

Funding Sources Yale University, Yale Peabody Museum, American Museum of Natural History

Technical Session 5: Amphibians & Early Reptiles (Thursday, November 3, 2022, 8:00 AM)

DESCRIPTIONS OF *MILLERETTA RUBIDGEI* AND *MILLEROPSIS PRICEI* (AMNIOTA, PARAREPTILIA) USING HIGH-RESOLUTION NCT WITH IMPLICATIONS FOR THE MONOPHYLY OF PARAREPTILES

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The origins and placement of Parareptilia among reptile-line amniotes have been difficult to ascertain, in part due to ontogenetic variation (e.g. the closing of the lower temporal fenestra through ontogeny) and the fact that ghost lineages of many subgroups of parareptiles are long, spanning much of the Permian. Parareptiles have been hypothesized either as one

of the earliest-diverging reptile lineages or in a more crownward position close to Neodiapsida (all taxa more closely related to *Youngina* than to *Petrolacosaurus*). Furthermore, although support for a monophyletic Parareptilia (including Mesosauridae, Acleistorhinidae, Bolosauridae, Millerettidae, and Procolophonomorpha) has been consistent, it is not well-supported. Millerettidae is often found as one of the earliest branching clades of parareptiles, even sister to all other clades, despite first appearing in the Guadalupian. However, recent work has suggested a more derived position for millerettids within Parareptilia as sister to Procolophonomorpha. We evaluate this using high-resolution synchrotron phase-contrast tomography, to document the crania of *Milleretta rubidgei* and the holotype of *Milleropsis pricei*. These scans reveal anatomy of the premaxilla, braincase, and palate that appear remarkably derived relative to other early reptiles, such as Captorhinidae and Araeoscelidae, therefore consistent with a crownward position for Millerettidae (and potentially other parareptiles). Relevant traits include a posterolateral process of the ectopterygoid similar to that of 'Younginiformes', a peg-like anteroventral process of the prootic contacting the parabasisphenoid (previously only documented in neodiapsids), and a basal articulation formed solely by the pterygoid, a possible synapomorphy of Neoreptilia (traditional Parareptilia + Neodiapsida). When we incorporate these observations into an expanded phylogenetic analysis of early amniotes we do NOT find support for the monophyly of traditional Parareptilia, with Millerettidae found as sister to Neodiapsida or as sister to Procolophonomorpha in a scattered "Parareptilia". Though unstable, both of these positions are more congruent with the relatively late appearance of millerettids. A review of parareptile anatomy, including characters interpreted as synapomorphies, reveal homoplasy within early reptile-line amniotes, demonstrating the need for caution when analyzing early reptiles without a sufficient sampling of both derived and outgroup taxa.

Funding Sources NRF AOP 118794, European Synchrotron Radiation Facility, ISU Graduate Research Grant, Bureau of Land Management

Virtual Posters

DIGITIZED ENDOCASTS AND BRAINS: MEASUREMENTS AND ANALYSES OF THE EVOLUTION OF 172 FOSSIL AND EXTANT VERTEBRATE SPECIMENS

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This project records brain evolution in vertebrates using 172 digitized endocasts of extinct and extant species spanning 60 million years. Three-dimensional (3D) images of 126 fossil endocasts, including Cenozoic mammals, *Bathygenys*, and dinosaurs, were quantified and compared with the endocasts and brains of extant species. Encephalization quotients and neocorticalization were calculated from digitized endocasts. On average, mammals became increasingly neocorticalized over time, increasing at an average of about 5% additional neocortex per 10 million years. About 60 million years ago, mammalian neocorticalization averaged about 20%, increasing to a present average of 50%, and reaching a maximum of about 80% in primates within the past 10 million years. These data redefine the allometric boundary between mammals and reptiles and confirm that measurements on a single species adequately represent the brains of the entire species.

Virtual Posters

PREAXIAL DOMINANCE IN THE DEVELOPMENT OF CARPUS/TARSUS OF SALAMANDERS AND IMPLICATIONS ON DIGIT REDUCTION DURING FIN-TO-LIMB TRANSITION

Jia, Jia¹, Anderson, Jason¹, Jiang, Jian-Ping², Wu, Wenhao³, Shubin, Neil⁴, Gao, Ke-Qin⁵

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The limb is a hallmark organ of tetrapods, and counterparts for most limb structures have been identified in sarcopterygian fish with the exception of distal carpals/tarsals. In early limb development (mesenchymal condensation and chondrification), salamanders have preaxial elements (e.g., digit II, radius) that form earlier than the corresponding postaxial elements (e.g., digit IV, ulna), and have certain elements in the hand or foot form from distally to proximally, in contrast to amniotes and anurans, in which the limb forms from proximally to distally with postaxial elements forming earlier than preaxial elements. Such differences were found as retained in late skeletogenesis of digits and zeugopod in anamniote tetrapods, whereas the ossification patterns of the carpus/tarsus (mesopod) remain unclear due to their cartilaginous nature or delayed ossification timing; and explanations on the peculiar preaxial dominance remain controversial. Here, based on μ CT scans of 214 specimens from six salamander clades, we show that preaxial dominance is restricted to the ossifications of distal or digital-arch carpals/tarsals in several salamander clades, temnospondyls, basal amniotes, and many early tetrapods, but is reversed in others (e.g., Salamandridae, Plethodontidae); non-digital-arch mesopodials ossify following the postaxial dominance with

element y and radiale/tibiale as the last to ossify; and the mesopod in most salamander clades ossifies from proximally to distally. Our results reinforce that modern tetrapods share a general bauplan in limb development and rejects hypotheses that preaxial dominance in salamander limb development is either a derived feature or an ancient mode confined within temnospondyls, but instead is a primitive developmental pattern in tetrapods. As exemplified by many last-to-form-and-first-to-loss cases in vertebrate evolution, preaxial dominance is argued to cause the loss of the postaxial distal carpals/tarsals in early tetrapods with more than five digits. We also found that distal carpals/tarsals and corresponding fingers/toes are lost in sequences opposite between early tetrapods and modern salamanders, and demonstrate that the distal carpals/tarsals are an important segment that is developmentally and evolutionarily independent in the hand/foot; and the preaxial dominance stabilizes the numbers of distal carpals/tarsals and promotes digit reduction during the fin-to-limb transition.

Funding Sources National Natural Science Foundation of China (41702002/41872008); Natural Sciences and Engineering Council of Canada Discovery Grant (2017-0482)

Technical Session 11: Synapsida (Friday, November 4, 2022, 8:00 AM)

TAXONOMIC REVISION OF THE TITANOSUCHIDAE (THERAPSIDA, DINOCEPHALIA) OF THE KAROO BASIN, SOUTH AFRICA: A KEY TO UNDERSTANDING MIDDLE PERMIAN TETRAPOD DIVERSITY

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Titanosuchidae are a group of derived herbivorous long snouted dinocephalians currently only known from the South African Karoo Supergroup. Taxonomic revision of the titanosuchids for the first time enabled recognition of only two genera each represented by a single species out of nine previously recognized species. These are *Titanosuchus ferox* and *Jonkeria truculenta*. *Jonkeria vanderbyli*, *Jonkeria ingens*, *Jonkeria haughtoni*, *Jonkeria parva*, *Jonkeria rossouwi*, and *Jonkeria boonstrai* are here synonymized with *Jonkeria truculenta*. The species *Jonkeria koupensis* is a *nomen dubium* only identified as titanosuchid indet.

Cranial characters, which modify during ontogenetic development, were recognized for *Jonkeria*, and for the first time an ontogenetic growth series is presented for this species. This research has for the first time produced a phylogenetic analysis of the two titanosuchid taxa with their deuterosaurid, estemmenosuchid, anteosaurid, styracocephalid, and tapinocephalid counterparts, confirming the sister group relationship between Styracocephalidae, Estemmenosuchidae,

Titanosuchidae, and Tapinocephalidae. This phylogenetic analysis manifests a long ghost lineage extending over most of the Guadalupian.

The first extensive stratigraphic analysis of the Titanosuchidae shows that the South African Karoo Supergroup hosts both genera in the upper levels of the Abrahamskraal Formation (Moordenaars Member) with a single specimen (titanosuchid indet.) recovered in the lower levels of the overlying Poortjie Member of the Teekloof Formation.

Funding Sources DST-NRF Centre of Excellence in Palaeosciences (Genus) and NRF African Origins Platform

Colbert Prize Session

A NEW SELENOSTEID PLACODERM FROM THE LATE DEVONIAN OF THE EASTERN ANTI-ATLAS (MOROCCO) WITH PRESERVED BODY OUTLINE AND ITS ECOMORPHOLOGY

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Placoderms are an extinct group of early jawed vertebrates that play a key role in understanding the evolution of the gnathostome body plan, including the origin of novelties like jaws, teeth and pelvic fins. As placoderms have a poorly ossified axial skeleton, preservation of the mainly cartilaginous axial and fin elements is extremely rare, contrary to the heavily mineralised bones of the skull and thoracic armour. Therefore, the gross anatomy of the animals and body shape are only known from a few taxa and reconstructions of the swimming function and ecology remain speculative. Here, we describe articulated specimens preserving skull roofs, shoulder girdles, most fins, and body outlines of a new derived arthrodire. Specimens of the new selenosteid display a skull roof with reticular ornamentation and raised sensory lines, a median dorsal plate with a unique sharp posterior depression, the presence of a pelvic fin through the preservation of a pelvic girdle, the proportions and shape of the pectoral, dorsal and caudal fins as well as a laterally enlarged region resembling a few modern sharks and bony fish' lateral keel. Our new phylogenetic analyses support the monophyly of the Selenosteidae family and places the new genus in a clade with *Melanosteus*, *Enseosteus*, *Walterosteus* and *Draconichthys*. The shape of its heterocercal caudal fin in combination with the pronounced 'lateral keel' suggest this animal was an active macropelagic swimmer capable of reaching high swimming speeds.

Funding Sources Melina Jobbins and Christian Klug are funded by the Swiss National Science Foundation (project number S-74602-18-01).

Technical Session 17: Fish (Saturday, November 5, 2022, 8:00 AM)

MECHANISMS OF DERMAL BONE REPAIR AFTER PREDATORY ATTACK IN THE GIANT STEM-GROUP TELEOST *LEEDSICHTHYS PROBLEMATICUS* SMITH WOODWARD, 1889 (PACHYCORMIFORMES)

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Leedsichthys problematicus is a member of the Mesozoic clade Pachycormiformes (stem-group Teleostei), and the largest known ray-finned fish (Actinopterygii). The skeleton is poorly ossified, but the caudal fin (tail) is well-preserved, including rounded bony calluses on the dermal fin rays. Although superficially similar to Tilly bones (regions of bone hyperostosis associated with the internal skeleton), when sectioned, the calluses in *Leedsichthys* show clear evidence of damage. Survival after this damage, proposed to result from a predatory attack by a large marine reptile coeval with *Leedsichthys* in the Jurassic seas, allows dermal bone repair mechanisms to be examined in considerable detail.

The distinctive tissue changes within the callus that are indicative of repair include resorption of the broken bone fragments and the surface of the lepidotrichium itself. In the process of repair, scalloped surfaces indicate resorption, providing evidence of active osteoclast surfaces; when these are buried by bone formation they remain as reversal lines. This resorption removes old bone and prepares the bone margin for the osteoblasts to return to form new bone, initially composed of many coarse fibres, and termed woven bone.

Within the woven bone, more radially arranged linear spaces suggest the presence of bundles of unmineralized collagen, identified as Sharpey's fibres. These fibres normally provide attachment of dermal bones to connective tissue, but here attach new bone to old. Developing woven bone surrounds a dense vasculature in the callus, which would have brought in stem cells committed to become bone-depositing osteoblasts. The woven bone is eventually replaced by a more laminar bone.

Although the timing of the attack and duration of the observed repair in *Leedsichthys* is unknown, in modern zebrafish, repair response to lepidotrichial crushing is incomplete, with the callus not fully resorbed and repaired. This could also be true of *Leedsichthys*, and a feature of teleost bone repair.

Technical Session 20: Crocodylomorpha (Saturday, November 5, 2022, 1:45 PM)

EVALUATING BODY SIZE DISTRIBUTION IN *MACROSPONDYLUS BOLLENSIS* (CROCODYLOMORPHA: TELEOSAUROIDEA) IN THE TOARCICAN POSIDONIA SHALE; GERMANY

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The Posidonia Shale Formation (Jurassic: Toarcian) of southern Germany has yielded an array of incredibly preserved fossil vertebrates, including fishes, ichthyosaurs and thalattosuchian crocodylomorphs. One of the most well represented clades in this formation is Teleosauroidea, a group of successful crocodylomorphs that dominated the coastlines during the Early Jurassic. While four teleosauroid species are present in the Posidonia Shale, the most notable and abundant is *Macrospondylus bollensis*. Individuals of this species range in skull length from 12 cm to over 100 cm, making *Macrospondylus* an ideal taxon for body size and ontogenetic studies. However, no previous studies have examined ontogeny and growth rates in teleosauroids, representing a major gap in the understanding of their biology.

Here we examine body size distribution within *Macrospondylus* and additional teleosauroids using linear regression and principal component analyses (PCA) implemented in PAST 2.17c. We compiled a dataset of 60 teleosauroids (including 52 *Macrospondylus* specimens) from the Posidonia Shale. Skull length was used as a proxy for biological age, dividing the specimens into three categories: juvenile (skull less than 20 cm), sub-adult (20 cm to 45 cm) and adult (skull over 45 cm). We evaluated the following: (1) rostral length vs. total skull length; (2) total skull length vs. total body size; and (3) forelimb (humerus+ulna+third metacarpal) vs. hind limb (femur+tibia+third metatarsal) length. In addition, we evaluated orbit, supratemporal fenestra, mandible and pelvic measurements. The linear regression results reveal that *Macrospondylus* displays isometric growth throughout the entirety of the body. In the PCA, skull length explains most of the variance along PCA1 (77%) and hind limb length explains most of the variance along PCA2 (15%). Our linear regression analyses signify unusual results, as modern crocodylians generally display some form of allometric growth (either in the skull or limbs). This suggests that *Macrospondylus* adopted unique growth strategies: younger individuals superficially resembled small adults and did not significantly remodel the body, notably retaining a disproportionately large skull into adulthood. In addition, the teleosauroid *Platysuchus multiscrobiculatus* plotted within the sub-adult category in terms of skull length but as an adult in all other skeletal aspects, suggesting a longer-limbed, more terrestrially-adapted species.

Funding Sources This research is supported by the Alexander von Humboldt Foundation.

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

BROAD COMPARATIVE ANALYSIS OF TYRANNOSAURID CRANIAL STRESSES AND BITE PERFORMANCE THROUGH MUSCLE FORCE RECONSTRUCTION AND FINITE ELEMENT ANALYSIS

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Adult *Tyrannosaurus* exerted a bone-splintering bite force between 35,000 and 60,000 Newtons, delivered via a cranium strengthened with fused nasals, a secondary palate, and functional akinesis. A few studies have explored feeding adaptations of other tyrannosaurids, but none has addressed cranial performance and inferred feeding behavior across the larger clade Tyrannosauoidea, including early-diverging tyrannosauroids (*Dilong*, *Proceratosaurus*, and *Yutyranus*). Here we broadly assessed the cranial performance and feeding function of various tyrannosauroids to investigate the evolution of feeding behavior in Tyrannosauoidea through muscle force reconstruction and finite element analysis.

We analyzed several tyrannosauroids of variable body size, including (smallest to largest): *Proceratosaurus*, *Dilong*, *Raptorex*, *Alioramus*, juvenile *Tyrannosaurus*, *Teratophoneus*, and adult *Tyrannosaurus*. New muscle forces for tyrannosauroid specimens were scaled from relative subtemporal fenestra areas, and forces of individual muscles already calculated for tyrannosaurine specimens of similar body sizes. Finite element analysis was used to quantify and evaluate cranial stresses of an anterior bite in tyrannosauroids, derived from modeled 3D geometry, *Alligator* skull material properties, and the calculated muscles forces.

Jaw muscle forces scaled predictably with increasing size in tyrannosauroids and in *Tyrannosaurus* and close relatives. The juvenile tyrannosaurid *Raptorex* had greater calculated muscle forces and experienced greater cranial stress than similarly sized earlier tyrannosauroids (*Proceratosaurus*, *Dilong*). This suggests that the juvenile condition of more derived tyrannosauroids delivered greater bite forces than small, early tyrannosauroids. While at similar body sizes, the juvenile

Tyrannosaurus demonstrated relatively higher jaw muscle force than *Alioramus* and the early deep-snouted tyrannosaurine *Teratophoneus*. Deep-snouted tyrannosauroids exhibited relatively lower cranial stress than gracile-snouted tyrannosauroids. This suggests that deep-snouted tyrannosauroids could resist high stresses and deliver relatively powerful bite forces.

With both high muscle force and stress, small juvenile tyrannosaurids over-performed forces versus earlier tyrannosauroids, and demonstrated strained cranial reinforcement adaptations that became more effective in adults.

Technical Session 11: Synapsida (Friday, November 4, 2022, 8:00 AM)

EVOLUTIONARY ORIGINS OF MAMMALIAN AXIAL FUNCTION REVEALED THROUGH DIGITAL BENDING EXPERIMENTS

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The origin of mammals from non-mammalian synapsids (NMS) represents an iconic locomotor transition, characterized by a change from reptile-like abducted limbs and lateral movements of the backbone to mammal-like adducted limbs and sagittal backbone movements. However, recent research has called into question the lateral-to-sagittal functional shift in NMS, instead suggesting that basal synapsids displayed a distinct functional regime and ancestral condition not observed in extant reptiles. To investigate this idea further, we used *Autobend*, a technique for estimating vertebral osteological range of motion (oROM) from skeletons using digital modeling. We applied *Autobend* to seven extant mammal and reptile species and 11 exceptionally preserved non-mammalian synapsids to estimate vertebral oROM and intervertebral joint stiffness. Results revealed a clear distinction between extant mammals and reptiles in oROM, with reptiles emphasizing lateral bending and mammals sagittal bending as expected. While most extant taxa exhibited relatively similar levels of stiffness in lateral and sagittal directions, extant lizards and salamanders displayed much more compliance in lateral bending and lower stiffness overall, in keeping with their observed axial kinematics. Conversely, most non-mammalian synapsids displayed an intermediate condition, with stiffer intervertebral joints than extant lizards, crocodiles, and therian mammals, but similar to the pattern recovered for the modern tuatara. The mammalian condition of sagittal mobility accompanied by axial twisting in the anterior column is first observed in the crownward tritylodontid cynodont *Kayentatherium*. Together, these results support previous assertions of a distinctive ancestral state for

vertebral function in synapsids characterized by high stiffness with neither the specialization for lateral bending of extant lizards nor the sagittal bending and twisting observed in mammals. This indicates a more limited role for the axial skeleton in terrestrial locomotion relative to extant groups, and a greater focus on body support than propulsion during the initial stages of synapsid evolution. Given the strong association between sagittal bending and asymmetric gaits in mammals, these results provide an important first step in reconstructing the evolution of synapsid locomotor patterns.

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Technical Session 7: Paleogene Mammals & Primates & Carnivora (Thursday, November 3, 2022, 1:45 PM)

RELATIONSHIP OF NYCTITHERES (MAMMALIA, NYCTITHERIIDAE) TO BATS AND OTHER LAURASIATHERIANS

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A possible relationship between nyctitheres (Mammalia, Nyctitheriidae) and bats has been recognized for over a century. Multiple nyctithere species were initially identified as bats and at least one bat has been initially described as a nyctithere. Despite their morphological similarities to bats, most studies consider nyctitheres to be eulipotyphlans or euarchontans and their relationship to bats has never been explicitly evaluated in a phylogenetic context. Recent descriptions of more dentally and postcranially complete nyctitheres have allowed for a more thorough understanding of nyctithere relationships, including possible affinities with bats. Here, we evaluate the relationship between nyctitheres, bats, and other members of Laurasiatheria using a data matrix consisting of 27 taxa and 699 morphological characters. Ten nyctithere species were included along with five species of stem bats and representatives of Eulipotyphla, Carnivora, Artiodactyla, and Perissodactyla. We find Nyctitheriidae to be nonmonophyletic as currently constructed. Our analysis finds several nyctitheres—including *Eosoricodon terrigena* and “*Wyonycteris*” *microtis*—to be most closely related to bats among the included taxa, whereas others are recovered sister to Carnivora or outside of crown Laurasiatheria. No nyctitheres in our analysis grouped with members of Eulipotyphla. Asian nyctitheres, in particular, appear relevant to the origins of both Chiroptera and Laurasiatheria. These results suggest that nyctitheres may be vital to understanding the evolution of multiple laurasiatherian clades, including bats.

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.

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

TAPHONOMIC COMPARISON OF TWO MONODOMINANT BONEBEDS OF *HYPACROSAURUS STEBINGERI* (HADROSAURIDAE: LAMBEOSAURINAE) FROM SOUTHERN ALBERTA AND MONTANA SHEDS LIGHT ON THE LIFE HISTORY OF HADROSAURS

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Ontogenetic changes in hadrosaur social structure is a subject of debate. Evidence from bonebeds suggests that juveniles were segregated from adults, but the timing of this age segregation is still poorly understood. Two bonebeds of juvenile individuals of the lambeosaurine *Hypacrosaurus stebingeri* from the upper Campanian Oldman Formation (Alberta, Canada) and Two Medicine Formation (Montana, USA) offer an opportunity to gain a better understanding of the behavior of young hadrosaurs. A total of 174 bones from the Alberta bonebed and 373 bones from the Montana bonebed, all accessioned at the Royal Tyrrell Museum of Palaeontology (Drumheller, Canada), were examined for signs of weathering, abrasion, fracture, wet rot, tooth marks, and trampling. The bones were assigned to Voorhies groups to assess hydraulic sorting. Linear measurements of long bones were used to assess the size of the individuals. Incomplete neurocentral closure and the small size of the individuals relative to adults attest to their juvenile status. Based on the number and size of fibulae and tibiae in the bonebeds, at least four similar-sized individuals (~51% of a fully-grown adult) are preserved in the Alberta bonebed, whereas the Montana bonebed preserves at least three smaller individuals of various sizes (~45%, 41%, and 36% of a fully-grown adult). Light skeletal elements are under-represented in both bonebeds. Bones show little signs of weathering and abrasion. Wet rot and transverse fractures are present on nearly all long bones. Tooth marks are observed on less than 2% of the bones. The uniformity of the taphonomic signatures of the bones preserved in the bonebeds suggests they are not time-averaged assemblages. The two bonebeds are interpreted to represent separate mass mortality assemblages of juvenile *H. stebingeri* individuals that died simultaneously. The Alberta bonebed is interpreted to represent a cohort due to the similar size of the individuals, whereas the Montana bonebed likely represents individuals of different ages. The Montana bonebed suggests that young hadrosaurs may have lived in groups of various sizes, potentially different ages, until they reached at least 45% of their maximum size, at which time they would have left the group to live with individuals of the same size as indicated by the Alberta bonebed, potentially from the same

cohort. As such, young *H. stebingeri* individuals were likely segregated sometime during the late juvenile stage.

Funding Sources FRQNT (Québec) (T. J.), Roger Soderstrom Scholarship (T. J.), Alberta Graduate Excellence Scholarship (T. J.), NSERC Discovery grant (D. K. Z.).

Technical Session 12: Rodents & Quaternary Mammals
(Friday, November 4, 2022, 1:45 PM)

A NEW CRANIUM OF *PALAEOLOXODON TURKMENICUS* (PROBOSCIDEA, ELEPHANTIDAE) FROM KASHMIR, AND THE DIVERSITY OF PROBOSCIDEANS FROM THE INDIAN SUBCONTINENT

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Quaternary sediments of the Kashmir Valley in Northern India represent the remains of paleolake, and are collectively called the Karewa Group. Unlike the more southerly Siwalik Group, the fossil record of the Valley is less-well known. However, excavations over the last several decades have revealed a small but diverse mammalian fauna, with the Quaternary sequences proving to be the most fossiliferous. An excavation of a quarry near Galandar Pampore yielded the remains of a remarkably complete *Palaeoloxodon* skull. The skull was found in a sandy channel within the Pampore Member of the Nagam Formation. Excavation of adjacent channel deposits revealed further fragmentary elephant remains and a series of 57 stone tools. The cranium preserves the third molars and partial tusks. The morphology of the cranium is intermediate between that seen in the Early Pleistocene *Palaeoloxodon recki* from East Africa and Israel, and Middle and Late Pleistocene *Palaeoloxodon namadicus* from the Indian Subcontinent, *Palaeoloxodon antiquus* from Europe, and *Palaeoloxodon naumanni* from Japan. Like *P. recki*, the Galandar specimen has a weak parieto-occipital crest, not extending beyond the facial plain; elongated and laterally flaring premaxillaries, and incipient loxodont sinuses on the molars. However, the wide frons is reminiscent of other Middle Pleistocene species of *Palaeoloxodon*. The nasal margins are also rounded, much like those seen in skulls of *Palaeoloxodon namadicus* from Central India. Parieto-occipital crest growth occurs during ontogeny, but the molar wear stage indicates that this specimen was an older individual, and there, it is unlikely that the crest would have

developed further. The mosaic characters seen in the Galandar specimen are also found in the poorly studied species *Palaeoloxodon turkmenicus* from Turkmenistan. While *P. turkmenicus* has been synonymized with *P. antiquus* by other authors, we regard *P. turkmenicus* as a distinct species, and refer the Galandar specimen to this taxon. *P. turkmenicus* likely represents an intermediate stage in the evolution of *Palaeoloxodon*. *Palaeoloxodon* was most likely widespread in South Asia, and perhaps entered the high montane valley by following riverine corridors. In addition *Elephas hysudricus* and cf. *Sinomastodon* are also known from the Pampore Member, a markedly different proboscidean fauna than found in Siwalik Group, but more similar to that from the Middle Pleistocene of Peninsular India.

Virtual Posters

ICHOLOGICAL EVIDENCE FOR A MULTI-AGED COLONY OF PTEROSAURS

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Pterosaurs, which first appeared in the Late Triassic, are the first and largest powered-flight vertebrates. Their sizes show great variety, with wingspans ranging from a few decimeters to about 10 meters. Recent studies have shown that pterosaurs' habitat, environment, and diet were very diverse, suggesting that they showed various types of survival strategies. In addition, it is becoming somewhat clear that at least some pterosaur groups lived in groups, following discoveries of bonebeds showing ontogenetic variation or colonial nesting behavior.

In the Jangdong Formation (latest Cenomanian) of the southwestern Korean Peninsula, we found at least three different types of pterosaur footprints on four different levels. Significantly, the eleven slabs that seem to originate from the single-layer comprise about 300 densely distributed (143 prints per square meter), manus-dominated, and various-sized tracks. The smallest manus is 21.50 mm, and the largest is 61.15 mm, showing congruence with each other and a continuous size distribution. The wingspan range of the trackmaker appears to be about 0.5 to 1.5 meters, but it is unclear whether the size distribution includes the adult of pterosaurs or only the juvenile or subadult of more giant pterosaurs. However, considering that the size of footprints found at different levels is also included in the same size range, it is highly likely that this area was a colony of small pterosaurs.

There have often been cases in which pterosaur footprints of different sizes have been found in the same tracksite (e.g., Tagragra of Morocco, Crayssac of France, Fukui of Japan, and Haenam & Jinju of Korea). However, it is difficult to consider

it as multi-generation in many cases, because they exhibit different morphology or discontinuous size distributions. This footprint assemblage, which is continuous in size, consistent in morphology, and found in very high density, will be ichnological evidence to support the multi-aged colony of pterosaurs.

Funding Sources Mudeungsan UNESCO Global Geopark Revitalization and Globalization Project by Gwangju Metropolitan City, Jeollanam-do Province, Damyang-gun County, and Hwasun-gun County

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

PALEOECOLOGICAL IMPLICATIONS OF NASAL TURBINATE MORPHOLOGY IN THE PALEOCENE MAMMAL *ERNANODON ANTELIOS*

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The nasal turbinates in mammals play a major role in the conservation of water and heat during respiration; this built-in ‘air conditioning’ allows individuals to acclimatize to a broad range of environmental conditions. Despite their functional importance, these structures are rarely studied in the fossil record, largely due to their fragility and thus low preservation potential. The skull of *Ernanodon antelios* (IVPP V5596), an enigmatic mammal from the late Paleocene Nongshan Formation of southern China, has well-preserved maxilloturbinates with unusually simplified and thickened morphology, offering a rare window into nasal turbinate functional morphology in an early Cenozoic mammal. We conducted microCT scanning and phylogenetic comparative morphometric analysis of turbinate thickness and spacing in *Ernanodon* with a diverse sample of extant mammal species that exhibit similar external skull morphology to and/or occupy ecological roles previously inferred for *Ernanodon*. Additionally, these thickness and spacing measurements were analyzed relative to ecological and environmental variables in the extant taxa examined. *Ernanodon* was found to have significantly thicker maxilloturbinates than all other taxa in the dataset, and relatively narrow spacing. Both thickness and spacing show low phylogenetic signal, suggesting potential as an indicator of ecology. Among extant taxa, turbinate thickness and spacing exhibit a general negative relationship with activity level, perhaps due to a greater need for water and heat conservation accompanying higher respiration rates. There is also a positive relationship with mean annual temperature and precipitation, further suggesting that turbinate morphology has the potential to be used as a paleoenvironmental proxy. The relationship between nasal turbinate morphology and environmental and ecological traits is a promising area of study, with implications for more robust

paleoecological inferences of *Ernanodon* and other fossil mammals.

Virtual Posters

FOSSORIALITY IN THE CYNODONT-MAMMAL TRANSITION SCENERY: EVIDENCE FROM *BRASILODON QUADRANGULARIS*

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Recent morphofunctional studies revealed that Mesozoic mammaliaforms displayed a diverse array of locomotor habits, from fossorial to arboreal (and even gliding), challenging the view that they were all insect-eating generalists. However, few studies of the kind have been done on their forerunners, the non-mammaliaform cynodonts. The small Probainognathian *Brasilodon quadrangularis*, from the Late Triassic of Brazil, is considered the sister taxon to Mammaliaformes and its postcranial skeleton offers a unique opportunity for morphoanatomical studies. As such, our goal was to identify the locomotor habits of *Brasilodon*, based on the specimen UFRGS-PV-1043-T. We followed Chen & Wilson’s (2015) approach, which is effective at inferring locomotor habits of Mesozoic mammaliaforms. The method consists in using data from living mammals, classified by locomotor habits, to “train” a discriminant linear analysis and using it to infer the habit of the target specimen. We took linear measurements and transformed those into morphometric indexes based on ratios. Indexes related to structures not preserved were excluded. Our analysis classified *Brasilodon* as semifossorial with high posterior probability (99.56%), contradicting previous studies that proposed it was a generalist, arguing that, although *Brasilodon* probably could dig, it lacks strict fossorial adaptations. *Brasilodon*’s hindlimbs were held in an erect posture, but its forelimbs were held in a semi-sprawling posture, which could be pushing it to the fossorial morphospace due to similarities with the postures of some fossorial mammals. To make sure that this did not affect our results, we excluded forelimb indexes most affected by posture and reran the test, which also classified *Brasilodon* as semifossorial, but with lower posterior probability (74.96%) and semiaquatic became the second most probable habit (18.28%). Indexes that best separate semifossorial and semiaquatic taxa are associated with structures not preserved in *Brasilodon*, but a semiaquatic habit is unlikely as no other line of evidence has indicated it and the semifossorial habit is supported by a high posterior probability. Our preliminary results show that *Brasilodon*’s postcranial skeleton is most similar to those of semifossorial mammals and that it probably could dig and burrow at this pivotal moment of the cynodont-

mammal transition and may indicate that fossoriality was a strategy shared by *Brasilodon* and the first Mammaliaformes.

Funding Sources CAPES, FAPERJ, CNPq (process number 307938/2019-0)

Technical Session 12: Rodents & Quaternary Mammals
(Friday, November 4, 2022, 1:45 PM)

PHYLOGENETIC RELATIONSHIPS OF EOMYIDAE TO OTHER CLADES WITHIN GEOMORPHA: NEW RESULTS FROM INCISOR ENAMEL MICROSTRUCTURE ANALYSIS

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The extinct family of Eomyidae comprises small- to medium-bodied myomorph rodents with a Holarctic distribution. The phylogenetic relationships of eomyids are not yet resolved. Craniodental characters place them as closest relatives to Geomyoidea in the infraorder Geomorpha including fossil and extant New World Pocket Mice (Heteromyidae) and Pocket Gophers (Geomyidae), and often also the extinct Heliscomyidae and/or Florentiamyidae. Here, we present results from lower incisor enamel microstructure analysis supporting the alternative view that Eomyidae should be placed outside Geomorpha. At a minimum age of late Eocene (Duchesnean/Chadronian), Eomyidae show a highly apomorphic schmelzmuster with longitudinally oriented, uniserial Hunter-Schreger bands (HSB) in a two- or three-fold portio interna (PI), not present in any of the other families. In fact, the three-fold PI in Eomyidae is a previous unknown feature and unique within Rodentia. Geomyidae and Heteromyidae on the other hand are unique in sharing modified radial enamel as biomechanical reinforcement of the lower incisors to prevent structural failure under increased reaction forces due to significant burrowing activities (including chisel-tooth digging), underground feeding, and feeding on abrasive, fiber-rich plants and plant parts. Modified radial enamel in Geomyoidea is present since the early Oligocene (earliest Arikarean) and a retained plesiomorphic character in some extant taxa. The extinct Heliscomyidae and Florentiamyidae show moderately derived schmelzmuster types, which are widespread among rodents and lack special adaptations as seen in Eomyidae and in Geomyoidea. From the enamel microstructure perspective, Eomyidae are very different, higher evolved, and should rather be regarded as sister group to Geomorpha, possibly together with

Pipestoneomyidae with whom they share longitudinal HSB already at Chadronian times

Funding Sources DCK: German Research Foundation KA 1556/2-1 and 2-2, YK: JSPS KAKENHI 18K13650, Generalitat de Catalunya, project I+D+i PID2020-117289GBI00 MCIN/ AEI/10.13039/501100011033

Technical Session 11: Synapsida (Friday, November 4, 2022, 8:00 AM)

THE FIRST RECORD OF *INOSTRANCEVIA* IN AFRICA INDICATES RAPID TURNOVER OF TOP PREDATORS ON LAND DURING THE TERMINAL PERMIAN

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The saber-toothed Permian therapsid clade Gorgonopsia consistently occupied top predator niches following the extinction of anteosaurian dinocephalians during the end-Guadalupian extinction. Gorgonopsians were themselves victims of the end-Permian mass extinction, but the stratigraphic ranges of individual gorgonopsian taxa have been poorly known historically. The largest African gorgonopsians, belonging to the subclade Rubidgeinae, have traditionally been assumed to go extinct at the Permo-Triassic boundary. Here, we present new data on the youngest known large-bodied gorgonopsians, from the Permo-Triassic boundary (PTB) site of Nooitgedacht 68 in the South African Karoo Basin. These specimens are not rubidgeine, and instead are referable to the genus *Inostrancevia*, a taxon previously thought to be a Russian endemic. The South African *Inostrancevia* specimens include two complete, well-preserved skulls, one associated with a nearly complete, articulated skeleton. Minor details of the cranium (proportional snout length, ‘pinching’ of the zygoma) indicate that these represent a new species of *Inostrancevia*, distinct from the well-known Russian *I. alexandri*. Incorporating historic records and new, high resolution stratigraphic mapping, we show that there is no evidence for rubidgeine survival to the traditional vertebrate-defined PTB (the separation between the *Daptocephalus* and *Lystrosaurus declivis* Assemblage Zones) in the Karoo. Instead, we argue that rubidgeines were early victims of ecosystem disruption preceding the end-Permian mass extinction and were replaced as top predators by Laurasian immigrant inostranceviine gorgonopsians. The reign of this latter group was itself short-lived, however; by the earliest Triassic, large gorgonopsians were extinct, and a different group of theriodonts (akidnognathid therocephalians) assumed the role of largest therapsid predator before themselves going extinct. The extinction and replacement of therapsid top predators in rapid

succession at the clade level underlines the extreme degree of ecosystem instability in the latest Permian and earliest Triassic, a phenomenon that was likely global in extent.

Technical Session 9: Mammals (Friday, November 4, 2022, 8:00 AM)

NEW FOSSIL MAMMALIAN ASSEMBLAGES AND FIRST RECORD OF OSTRICH FROM THE PINJORE FORMATION (2.58–0.63 MILLION YEARS) OF THE INDIAN SIWALIKS

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The Pinjore Formation of the Upper Siwalik Hills, north of Chandigarh, provides one of the most extensive and the only continuous exposure of Quaternary deposits in northern India. Since the early 19th century, scholars have been involved with extensive surveys and comprehensive fossil collections from the region. However, most fossils were discovered as exposed parts of surface deposits. New palaeontological surveys were initiated in 2020 to identify *in-situ* fossil scatters to understand palaeoecological and palaeodietary shifts in fauna within the Pinjore deposits (2.58–0.63 Ma). As a result, six new palaeontological localities were discovered in the region, with 981 fossil specimens (dental, post-cranial and fossil eggshells). The post-cranial remains are fragmentary and undiagnosable, and dental remains can be identified to eight mammalian species of bovids, equids, and rodent. Fossilised ratite eggshells were also discovered and collected from four separate scatters across the locality of Choti Badi Nangal, and can be provisionally assigned to *Struthio camelus* cf. *molybdophanes*. This is also the first report of fossilised ratite eggshells from the Upper Siwalik Hills of India.

Funding Sources Paleontological Society; The Royal Anthropological Society; Lithic Studies Society; The Leakey Foundation

Technical Session 7: Paleogene Mammals & Primates & Carnivora (Thursday, November 3, 2022, 1:45 PM)

THE MOST COMPLETE SKELETON OF HOMUNCULUS PATAGONICUS (PLATYRRHINI, PRIMATES) FROM THE EARLY MIOCENE, ARGENTINA, IMPROVES ESTIMATES OF BODY SIZE AND RELATIVE ENDOCRANIAL VOLUME IN A STEM PLATYRRHINE

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Living New World monkeys (Platyrrhini) and Old World monkeys (Cercopithecoidea) have similar brains, both in terms of relative size and structural organization. However, fossil endocasts suggest that the last common ancestor of anthropoids had a brain that was structurally more plesiomorphic and much smaller relative to body size than any extant anthropoid. If so, brain evolution in platyrrhines and cercopithecoidea has been subject to considerable homoplasy. The earliest fossil platyrrhine taxa to preserve substantial endocranial anatomy include the early Miocene (~20 Ma) stem genera *Dolichocebus*, *Chilecebus*, and *Tremacebus*, and the younger (~17 Ma) genus *Homunculus*. Among these genera, only the endocast of *Chilecebus* has been described in detail. Thus, many questions remain about convergent brain evolution in modern neotropical and paleotropical anthropoids.

Here we describe the endocast of MPM PV 17453, a skeleton of *Homunculus patagonicus* representing the best-preserved and most complete remains discovered to date of a fossil platyrrhine prior to the Pleistocene epoch. The new specimen is the oldest known of *H. patagonicus* and includes the complete cranium with associated mandible, elements of the axial skeleton, limb girdles, humeri and femora. The cranium, along with those of five other undescribed crania of *Homunculus*, permit a detailed examination of endocast morphology using micro-CT scans. The new specimen is also the first of a stem platyrrhine in which evidence of endocranial size and morphology is directly associated with postcranial fossils. Body mass was estimated from cross-sectional midshaft area of the humerus and femur using phylogenetic independent contrasts on a consensus tree that included branch lengths of 49 extant euarchontans and *Homunculus*. The average of two estimates is 2,164g, a more precise estimate of body mass than those derived from isolated bones and teeth. Endocranial volume (ECV) of MPM PV 17453 was between 19–20cc. The ECV of *Homunculus* was thus relatively smaller than any living anthropoid and within the range of extant strepsirrhines. The frontal neocortex of *Homunculus* was also relatively small, as in living strepsirrhines. Nevertheless, the *Homunculus* endocasts resemble extant anthropoids in exhibiting relatively small olfactory bulbs. These results provide additional evidence that increases in the relative size of the brain and frontal neocortex evolved independently in neotropical and paleotropical anthropoids.

Funding Sources NSF BNS 1349741 to RFK and 1232534 to RFK and KA

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

PATTERNS AND PROCESSES OF SIMPLIFICATION IN THE TEMPORAL SERIES OF STEM TETRAPODS

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Throughout the evolutionary history of Tetrapoda the skull has been repeatedly simplified in both the anamniote and amniote lineages. This trend is first seen in the tetrapodomorphs as the number of elements of the dermal skull reduces from ~75 in the bony fish *Eusthenerpeton*, to ~30 in *Acanthostega* and *Ichthyostega*. The loss in complexity is even more extreme in lissamphibians which only have ~20 components to their skull roof. Although this reduction in the dermal skull is a significant and well-known phenomenon in tetrapod evolution, very little work has been done to investigate the overall pattern(s) of simplification and the developmental processes behind it. What little research has occurred has largely focused on the amniote lineage, with a particular focus on temporal fenestration. The temporal series (which consists of the intertemporal, supratemporal, and tabular) sees the greatest degree of variance within the stem tetrapod phylogeny, both within the anamniote and amniote lineages. Here, we have mapped the presence and absence of each element of the temporal series amongst the stem tetrapods using reconstructions of skulls from the literature. We compared these patterns in a number of different phylogenies, consisting of a broad range of early tetrapod taxa. In doing so, it becomes apparent that the temporal series reduces in a distinct pattern, whereby the intertemporal is the first to disappear, followed by the supratemporal, and then the tabular. This would suggest that the individual elements of the temporal series do not form a developmental module. To determine what evolutionary processes could be behind this pattern, we compared the loss of each element to different factors such as lifestyle and skull length. Interestingly we found no apparent correlation between mode of life (i.e. aquatic, amphibious, terrestrial, fossorial) to the reduction of the temporal series. As far as we are aware, these are novel findings and highlight the value of investigating developmental patterns and processes in both the anamniote and amniote lineages.

Funding Sources DFG grant

Symposium: A Late Miocene Shangri-la (Wednesday, November 2, 2022, 1:45 PM)

CLOSE AND YET SO FAR: COMPARING THE PRIMATE FAUNAS IN THE LATE MIOCENE OF YUNNAN, CHINA

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There are three principal late Miocene primate-bearing sites within a few hundred km of one another in Yunnan Province, China: Yuanmou (~8.2-7.1 Ma), Lufeng (~6.9-6.2 Ma), and

Shuitangba (~6.5-6.0 Ma). Primate higher-level taxonomic diversity among the three sites, including representatives of Sivaladapidae, Pliopithecidae, Cercopithecidae, Hylobatidae and Hominidae, is equivalent to that of the roughly 5-6 million-year span of primate-bearing horizons in the Miocene Siwalik Sequence of Pakistan and India. Between-site differences in Yunnan are equally striking, at both higher and lower taxonomic levels. All sites have a hominid while two have sivaladapids, but Pliopithecidae, Cercopithecidae and Hylobatidae are represented at only one site each. Moreover, different hominid species may be present at each site and the two sites preserving sivaladapids have different species. Of particular interest are the smaller-bodied primate taxa, which are present and diverse at both Yuanmou and Lufeng, but seemingly absent at Shuitangba. All sites have abundant micromammal and other small fossil remains, so the absence of small-bodied primates at Shuitangba appears to be real and not an artifact of collecting bias. Given the proximity of the Yunnan sites, it is unlikely that geography alone can explain this and the other differences in the primate faunas. Possible explanations include differences in time, depositional environment and taphonomy, paleohabitat, and also orogen-mediated vicariance. Time differences between sites, while not great, may have had greater impact on primate faunal composition during the very latest Miocene than earlier. Lufeng and Shuitangba mostly consist of lignite and carbonaceous clays (with fossils more concentrated in lignite at the former and in clays at the latter), while Yuanmou represents fluvial deposition. Shuitangba is unusual in being dominated by its diverse avifauna. Latest Miocene topography is reconstructed as having been not dissimilar from that at present, with the region showing complex topographic relief. Thus, it is likely that no one variable explains all differences in the primate faunas between sites. The presence of a cercopithecoid at Shuitangba but not elsewhere may relate to the late age of this site, while species differences among hominids and sivaladapids may reflect topographic isolation. None of the posited variables can be excluded as an explanation for the absence of small-bodied primates at Shuitangba.

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Technical Session 12: Rodents & Quaternary Mammals (Friday, November 4, 2022, 1:45 PM)

ECOLOGY AND EVOLUTION OF GIANT KANGAROOS OF THE PLIO-PLEISTOCENE GENUS *PROTEMNODON*

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Megafaunal kangaroos were diverse and widespread across Australia and New Guinea before becoming extinct by 40,000 years ago. Members of the genus *Protemnodon* Owen, 1874 were among the largest and most robust species, with body masses approaching 180 kg. Although *Protemnodon* was raised nearly 150 years ago, poor delineation of species and increasingly unclear generic identity have perpetuated taxonomic uncertainty. Here we clarify the systematics of this key group of marsupial herbivores and reveal that a major driver of this confusion was an over-reliance on morphology of the cheek dentition, which is far less useful for differentiating species than features of the postcranial skeleton. In total, we recognise seven species, three of them new, and produce a well-supported phylogenetic hypothesis. We also highlight unexpected variation in locomotory adaptations inferred from major differences in limb morphology and proportions. We relate these to species distributions and habitats. Species of *Protemnodon* are united by anatomical features that reflect stability and power in the limb joints during locomotion, as exemplified in the enlarged ilium and broad femoral proximal end, which bears well-developed muscle attachments. One of the two new Pleistocene species was a robust, low-gearred, bipedal hopper likely adept in uneven, better-wooded habitats. By contrast, the other of the two new Pleistocene species was larger but more gracile, convergent in some traits on modern, high-gearred, grey and red kangaroos. This and their wide inland distribution point to adeptness in open terrain. The third Pleistocene species, *Protemnodon anak*, was intermediate, a large, mid-gearred hopper of forests and woodlands of eastern Australia. The Pliocene *P. otibandus* of New Guinea displays adaptations to slower hopping, while its Pleistocene successor, *P. tumbuna*, is convergent on the morphology of modern New Guinean forest wallabies, and was likely facultatively quadrupedal. This research bolsters the emerging view that large kangaroos exhibited a much greater diversity of locomotor adaptations than has generally been perceived.

Funding Sources Royal Society of South Australia - small research grant, Flinders University - HDR student overseas field trip grant & development grant, UCMP - Welles Research Fund

Technical Session 16: Hoofed Mammals (Saturday, November 5, 2022, 8:00 AM)

MIDDLE MIOCENE UNGULATES FROM THE SIWALIK HILLS OF PAKISTAN: SYSTEMATIC AND BIOGEOGRAPHIC IMPLICATIONS

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The Siwalik subgroup of Pakistan has been debated with regards to its systematics and chronostratigraphic framework. Certain aspects of the biogeography and systematics of this subgroup would benefit from new data collected during different chronological intervals, including the Middle Miocene. Thus, a detailed paleobiogeographic and taxonomic investigation was undertaken on the fossil mammalian material from the Middle Miocene Siwaliks of Northern Pakistan. Fifty-two fossil remains included in this study were collected from several localities of the Middle Miocene Siwalik subgroup of Pakistan. Fossil families recovered include the Bovidae, Giraffidae, Suidae, Tragulidae and Rhinocerotidae. The material is housed at the Ecology and Evolutionary Biology Laboratory, 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 reviewed to address the possible factors which drove the paleobiogeography of Middle Miocene mammals of the Siwaliks by using the stable isotopes of carbon and oxygen and enamel hypoplasia analysis. The carbon and oxygen isotope values indicate that the Middle Miocene Siwaliks of Pakistan was exclusively a C3 vegetational system 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 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 Middle Miocene. Another possible factor was the regression in sea level which exposed the routes from one continent to another and caused faunal exchanges till the start of Middle Miocene. This study adds to the broader literature on the mammalian fauna and paleobiogeography of the Middle Miocene Siwaliks of Pakistan.

Virtual Posters

NEW DENTAL REMAINS OF ANISODON SALINUS FROM THE POTWAR PLATEAU, PAKISTAN

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Imagine the love child of a gorilla and a draught horse and you may perhaps envision a chalicothere. These fascinating and distinctive perissodactyls with low-crowned cheek teeth and claws rather than hoofs have no modern analog. Chalicothere

remains are found in Asia, Europe, Africa and North America, even into Panama. However, fossils of chalicotheres are rare, typically comprising only a small part of any fossil assemblage. Such paucity of material makes determining the evolutionary history and interrelationships of chalicotheres a challenge, and every new find may add new information. Here, we describe several new fossils from the Siwalik region of Pakistan and discuss their importance for understanding the chalicotheres of the region.

Chalicotheres are unusual clawed perissodactyls with a global fossil record, yet typically are rare elements of fossil assemblages, certainly so in the Siwaliks. We describe new dental remains from four localities within the Chinji Formation (14-11 Ma), Lower Siwaliks of Pakistan. We attribute the new specimens to *Anisodon salinus* (previously *Chalicotherium salinum*). The new specimens add new information about the morphological distinctiveness of *A. salinus*, and provides data about metrical variations with this species.

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

A NEW CATHARTID FROM RANCHO LA BREA AND ITS IMPLICATIONS FOR VULTURE BIODIVERSITY

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The fossil record for avians is incredibly poor due to the fragile nature of bird skeletons. The Rancho La Brea locality of southern California is an exception to this rule as it preserves undistorted elements of medium to large-bodied birds in excellent condition. Here, we describe a new species of *Coragyps* (Aves: Cathartidae) based on a near complete fossil cranium from the Late Pleistocene asphalt deposits of Rancho La Brea and discuss its importance to vulture biodiversity and evolution. The new species is differentiated from other modern and fossil *Coragyps* species by a foramen magnum that is tall and laterally compressed; orbits that are anteriorly elongated rather than hemispherical; a deep lateral excavation along the postorbital processes; and occipital and paroccipital processes that are less developed than other closely related taxa. This new species is the second *Coragyps* species recognized from the Rancho La Brea locality and only the third known extinct species in the genus. Modern vulture taxa in North America are limited to two species: *Cathartes aura* and *Coragyps atratus*. This is a much smaller number of species than those that those found outside of the North American continent (e.g. Africa, n=7), thus hinting at a higher biodiversity of vultures in the past. Considering the small numbers of modern *Coragyps* species and at least double the number of species described from the fossil record, this new specimen provides fossil evidence that North American vulture biodiversity was higher during the Late

Pleistocene than it is today. However, the exact mechanism for the reduction in vulture biodiversity is currently unknown. Moreover, the presence of a new species makes the relationship between *Coragyps occidentalis* and *Coragyps atratus* uncertain since both are considered to be anagenetic. Interspecific relationships between *Coragyps* species should remain inconclusive until associated or articulated cranial and postcranial remains are described.

Technical Session 7: Paleogene Mammals & Primates & Carnivora (Thursday, November 3, 2022, 1:45 PM)

HOMINOID EVOLUTION IN OPEN WOODLAND HABITATS: EVIDENCE FROM THE EARLY MIOCENE OF UGANDA

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Given that modern hominoids typically inhabit forested ecosystems and key traits of hominoids reflect adaptations for arboreality, it has traditionally been assumed that hominoids evolved in forested habitats. To investigate the paleoecological context of early hominoid evolution, multiple environmental proxies were collected and analyzed at the early Miocene fossil site complexes of Moroto (21 Ma), Napak (20 Ma) and Bukwa (19 Ma) in eastern Uganda. A compilation of paleoenvironmental indicators, including isotopic analyses of pedogenic carbonates, paleosol bulk organics and plant wax *n*-alkanes, as well as an evaluation of phytoliths and Mean Annual Precipitation (based on paleosol elemental chemistry), indicate habitat heterogeneity most consistent with seasonal woodlands with open grassland and riparian forest components for all three site complexes. These data include evidence of a significant C₄ biomass as understory grasses in broken-canopy habitats with gaps between trees, potentially similar to modern savanna landscapes. Isotopic signatures of Ugandan fossil herbivores (normalized to the pre-industrial d¹³C₁₇₅₀ atmospheric value), range from -6.3‰ to -15.9‰, reflecting variable diets, potentially including C₃ plant parts growing in closed canopy conditions, to water-stressed C₃ vegetation, and possibly a C₄ component. However, most values are confined between -12 and -8‰, reflecting ¹³C enriched dietary signatures relative to the range of herbivores in modern C₃ dominated closed canopy forest environments. Instead, these values are more consistent the isotopic range characterizing modern herbivores foraging in open forest to dry woodland habitats. Dietary carbon isotopic signatures of *Morotopithecus*, aff.

Rangwapithecus, and a proconsulid from the Moroto site complex reveal that all three hominoid taxa exhibit ^{13}C enriched diets (-10.3 to -9.4‰) relative to all modern African hominoids analyzed isotopically. These signals indicate dietary niches and habitat preferences distinct from those of living African apes, more similar to the isotopic range of monkeys such as *Papio* that forage in more open habitats as well as some of dietary signatures of the earliest hominins. Collectively, paleoecological proxies from the early Miocene of Uganda suggest that the early phases of hominoid evolution should be interpreted in an environmentally diverse context that includes broken canopy forest to open woodland habitats.

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

VULTURE FEEDING GUILDS FROM THE LATE PLEISTOCENE TO THE MODERN DAY: A GEOMETRIC MORPHOMETRIC APPROACH

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All species of the family Cathartidae, and some species of the family Accipitridae, are members of a group of birds called ‘New World’ (the Americas) and ‘Old World’ (Africa, Asia, and Europe) vultures, respectively. Vultures are obligate scavengers with a fossil record dating back to the early Eocene. Despite their common diets and characteristics, the ‘New World’ and ‘Old World’ vultures are not closely related. Rather, these groups have converged on similar morphologies that allow for a scavenging lifestyle. Previous research has suggested that these groups have also independently evolved into separate feeding guilds, thus allowing them to coexist while exploiting the same food source. This study reevaluates the currently proposed feeding guilds of New and Old World vultures by using 2D geometric morphometrics (GM) and principal component analyses (PCA) to examine the skull variation in these and other birds species that have been known to primarily scavenge, such as the Polyborinae (Falconiformes: Falconidae). Fossils from the Rancho La Brea tar pits are also included in these analyses to provide context on how this vulture guild structure in North America has changed since the Late Pleistocene and how it compares to what we see in today’s vulture populations of Africa, Asia, and Europe. A one-way analysis of variance test found that the accipitrid and cathartid vultures are statistically significantly different from each other in the shape of their skulls, but accipitrid vultures are more similar to cathartid vultures than to other species in the Accipitridae. Additionally, preliminary PCA analysis data shows that the skull shapes do not follow the groups defined by previous studies, indicating that other factors may be influencing skull shapes in vultures or these guilds may need to be redefined to more clearly illustrate the interactions between vulture species while feeding.

Funding Sources University of California Museum of Paleontology, University of California Museum of Vertebrate Zoology

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

NEW DATA ON *UTAHRAPTOR* RECOVERED DURING PREPARATION OF A MASS MORTALITY ASSEMBLAGE: DOES TAIL MORPHOLOGY DIFFERENTIATE DROMAEOSAURINES FROM VELOCIRAPTORINES?

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We interpret that a large 9-ton block of sandstone and mudstone collected from the Valenginian (135–136 Ma) upper Yellow Cat Member of the Cedar Mountain Formation at Utahraptor Ridge north of Arches National Park represents a large-scale dewatering feature (quicksand) that resulted in the burial of numerous theropods along with two iguanodonts. The presence of teeth in all the jaws and degree of articulation of skeletons indicates that the quicksand killed the animals and buried them. The skeletons are largely restricted to the sandstone portions of the block. The theropods are interpreted as representing a growth series of *Utahraptor*, perhaps representing a “pack” attracted to the deathtrap by the iguanodonts. The smaller individuals appear to break out into two size classes—the smallest would have had skulls ~10 cm long (minimum of 3) and larger specimens with skulls ~25 cm long (minimum of 5), interpreted to represent two reproductive cycles. A full adult is also represented with a reconstructed skull length of 60 cm together with a few intermediate sized animals. Given the different proportions of the limb elements and the maxillae, there is debate among the authors whether more than one theropod taxon is in the block or if ontogeny alone can explain these differences. An exposed adult or large subadult scapula-coracoid indicates that the shoulder girdle in *Utahraptor* is more conservative in its morphology, as in *Deinonychus*, compared to the more bird-like-derived condition of other dromaeosaurids like the unenlagiines, microraptorines, and *Velociraptor*.

Several articulated tail sections have been exposed in the block that represent both an adult specimen and several juveniles. The tails are similar in their distal portions having elongate centra with elongate, cylindrical zygapophyses that extend over the length of the adjoining vertebral column, unlike the hyper elongate zygapophyses that extend over several vertebrae in microraptorines and velociraptorines. They appear to be most similar to the distal caudal vertebrae in *Achillobator*, *Yurgovuchia*, and *Dakotaraptor*. *Archaeopteryx* and the unenlagiines have much shorter zygapophyses. Interestingly, a velociraptorine tail has been recovered from the *Utahraptor* faunal level 6 miles (10 km) to the east,

demonstrating that both dromaeosaurines and much less common velociraptorines occur in the Valenginian of Utah.

Funding Sources Funding: Utah Geological Survey, Wayne and Karen Lattuca, Many donors to gofundme.com/Utahraptor, Cross Marine Projects

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

MORPHOMETRICS AND FUNCTION OF THE ORNITHISCHIAN FEMUR AND FOURTH TROCHANTER

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Early ornithischians were small-bodied bipeds that possessed characteristic femoral morphology, including a bowed shaft and 'pendant' shaped fourth trochanter (4TR). Later, larger-bodied ornithischians had straight femora and a compressed, triangular shaped 4TR. The form of the 4TR may have functional significance, as it provides attachment sites for the powerful caudofemoralis muscles, and femoral curvature may improve load resistance. While the variation present in the ornithischian femur and 4TR has long been recognised, a broad quantitative study that considers phylogeny and function has been lacking.

We assembled a dataset of 8 linear measurements for the femora of 45 ornithischian taxa. For 41 of these taxa, we also recorded the two-dimensional, lateral shape of the 4TR using 3 landmarks: the proximal origin, the tip (point of max. curvature), and the point of distal termination, with 7 sliding semilandmarks in between. Principal component analysis (PCA) of the linear and geometric datasets, and a two-block partial least squares (PLS) analysis of the covariation between these sets, were applied with the statistical software R, and phylogenetic correlations were assessed.

For the linear PCA, PC1 accounts for ~90% of the variance, driven primarily by size, and PC2 accounts for ~7%, inversely driven by the index of femur curvature. For the geometric PCA, PC1 represents ~77% of the variance, correlating with an increasingly proximal position of the 4TR tip, while PC2 accounts for ~11% of the variation, correlating with an increasingly posterior projection of the tip. The distribution of taxa reflects phylogeny, with early-branching ornithischians being small-bodied, with curved femora and low geometric PC1 scores. A two-block PLS test ($r\text{-pls} = 0.613$, $p\text{-value} = 0.001$, $Z = 3.038$) demonstrates a significant association between geometric and linear datasets. A plot of PLS X vs Y scores was used to visualise variation in body size against the proximo-distal position of the 4TR tip. Functionally, a distally extended 4TR tip may increase mechanical advantage during femur retraction. Several small-bodied taxa, including the burrowing *Oryctodromeus*, and proposed burrowers

Koreanosaurus, *Nanosaurus*, and *Psittacosaurus* exhibit a high distal extension of the 4TR tip, suggesting this may represent a proxy for burrowing or digging behaviours. A trait similar to the enlarged third trochanter of contemporary mammalian femur-driven diggers (*Orycteropus afer*, xenarthrans).

Technical Session 2: Paleoecology (Wednesday, November 2, 2022, 8:00 AM)

NEW LATE TRIASSIC PALEOCOMMUNITY RECALIBRATES THE RISE OF THE MODERN TETRAPOD EVOLUTIONARY FAUNA, PLACING NEW CONSTRAINTS ON EARLY MESOZOIC EXTINCTIONS

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Late Triassic extinctions of temnospondyl, synapsid, and reptile lineages that explosively radiated after the end-Permian Mass Extinction (~252.5) marked a major transformation in non-marine tetrapod faunas, leaving a residual survivor-fauna of lineages that would compose nearly all taxa in terrestrial tetrapod paleocommunities by the Early Jurassic. The end-Triassic Mass Extinction (~201.5) could drive this transition; however, the depauperate record of Late Triassic assemblages representing well sampled non-marine tetrapod paleocommunities places poor constraints on patterns of extinction, survivorship, and community stability over this crucial interval. A new Late Triassic mixed macro-micro-vertebrate assemblage from the lower part of the Chinle Formation of Arizona, USA, has yielded an exceptionally diverse paleocommunity of terrestrial and semi-aquatic tetrapods from the humid continental paleotropics of central Pangaea. This assemblage resembles Early and Middle Jurassic continental paleocommunities in the presence of gymnophionomorphs, salientians, salamander-like lissamphibians, eucynodonts, rhynchocephalian and lizard-like lepidosaurs, pantestudines, crocodylomorphs, pterosaurs, and dinosaurs. Although most of these taxa are known individually from Triassic strata elsewhere, their precocious Triassic co-occurrence is unique, imposing a major recalibration on the initial assembly of paleocommunities including these early members of the modern tetrapod evolutionary fauna (and their physiological, locomotory, and ecological innovations) from the Early Jurassic to over 20 Ma earlier in the Late Triassic. Also present in this assemblage are metoposaurid and non-metoposaurid trematosauroid temnospondyls, colognathids,

drepanosauromorphs, tanystropheids, allokotosaurids, *Vancleavea*, *Uatchitodon*, phytosaurs, diverse aetosauroforms, poposaurids, and lagerpetids; all lineages that go extinct prior to the Triassic-Jurassic boundary. The middle Norian (~220 Ma) age of this assemblage indicates that subsequent Late Triassic extinctions eliminated the latter groups while the former survived to comprise nearly all tetrapod diversity from the Early Jurassic onwards, constraining the interval of these extinctions to the final 20 million years of the Triassic, and consequently casting doubt on the end-Triassic Mass Extinction as the sole driver of this pivotal transition.

Funding Sources Petrified Forest National Park, Friends of Petrified Forest National Park, Virginia Tech Department of Geosciences, National Science Foundation

Technical Session 17: Fish (Saturday, November 5, 2022, 8:00 AM)

HOW TO TUNA FISH: HIGH PHENOTYPIC INTEGRATION AND STRONG PHYLOGENETIC SIGNAL SUGGEST NEUROCRANIUM SHAPE EVOLVED EARLY IN THE DIVERGENCE OF PELAGIARIAN FISHES

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The skulls of teleost fishes are composed of a large number of kinetic elements. A notable exception to this is the neurocranium, to which kinetic elements of the suspensorium, upper jaw and operculum are attached, and its shape has an important influence on streamlining. The neurocranium must therefore perform numerous functions while maintaining a rigid structure. Thus, understanding its evolution is an important step in understanding the evolution of the teleost skull.

Skull shape evolution in tetrapods has been explored with 3D geometric morphometrics, but teleosts have been largely overlooked due to their anatomical complexity and the large number (~30,000) of extant species. Modularity, or the tendency of elements to form semi-independent developmental and evolutionary ‘modules’ may help tackle the issue of cranial complexity, and focussing on a single clade reduces the number of specimens required while allowing a comprehensive analysis of neurocranium evolution. The morphologically diverse clade Pelagiaria contains ~280 extant species, including taxa such as tuna and mackerel, making it a good candidate for study.

Using 3D shape data, we analysed neurocrania from over 80% of extant pelagiarian genera. The neurocranium shows high morphological integration. High shape variation in the supraoccipital crest and frontal is reflected in the major trends of shape variation across the dataset, from the elongate, narrow Trichiuridae to the short, deep Nomeidae, and suggests that streamlining is an important driver in neurocranium shape evolution. Neurocranium shape has a strong phylogenetic signal ($K_{\text{mult}}=1.1$), and evolutionary rates are correlated with morphological disparity. The combination of high integration with high phylogenetic signal suggests that neurocranium shape was established early in the evolution of the various families within Pelagiaria and has remained fairly stable since.

Funding Sources This project is funded by a Leverhulme Trust grant

Virtual Posters

NEW THERIZINOSAURID DINOSAUR FROM THE MARINE OSOUSHINAI FORMATION (UPPER CRETACEOUS, JAPAN) PROVIDES INSIGHT FOR FUNCTION AND EVOLUTION OF THERIZINOSAUR CLAWS

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The record of therizinosaurs is rich in Asian countries such as Mongolia and China. Fragmentary therizinosaur specimens have been reported from the Lower and Upper Cretaceous deposits in Japan. One of these specimens, from the lower Campanian Osoushinai Formation in Nakagawa Town of Hokkaido Prefecture, was previously identified as a maniraptoran theropod dinosaur, possibly therizinosaur, but its taxonomic status remained unresolved. This study re-examines the specimen and provides a more detailed description and attempts to resolve its taxonomic status. Our study demonstrates that it is a new taxon because it shows a unique combination of characters in the metacarpal I and unguals. Our phylogenetic analysis places this new taxon within an unresolved clade of Therizinosauridae in the strict consensus tree. The 50% majority-rule consensus tree shows better resolution within Therizinosauridae, showing an unresolved monophyletic clade of the Hokkaido taxon, *Therizinosaurus*, *Suzhousaurus*, and the Bissekty form. Geometric morphometric analysis suggests that unguals of the Hokkaido taxon most closely resemble *Therizinosaurus* unguals in being

slender and has weak flexor tubercles. This study also shows an evolutionary trend in ungual shape, which associates a decrease in mechanical advantage, development of flexor tubercle, and hypothesized output (product of mechanical advantage and development of flexor tubercle) in derived therizinosaurs, supporting the hook-and-pull function of claws to bring vegetation to its mouth. The Hokkaido taxon is the youngest therizinosaur from Japan and the first recovered from the marine deposits in Asia. This suggests a long temporal existence of therizinosaurs at the eastern edge of the Asian continent and adaptation of therizinosaurs to coastal environments.

Virtual Posters

COMPARING CARDIOVASCULAR ANATOMY OF AVIAN SPECIES ACROSS FLYING STYLE

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The heart is one of the most crucial organs in all vertebrate species and is responsible for pumping blood throughout an organism's body via the circulatory system. The heart's structures, size, stroke volume, and integrity are influenced by the active lifestyle of all species and therefore have specifically evolved to perform with accuracy and precision in all species. The stroke volume of the heart, limited by ventricular size, is responsible for the delivery of oxygen and, in aerobically demanding activities such as powered flight, can be a limiting factor for the capabilities of a flying animal. The capability for powered flight is one of the most unique innovations of vertebrate evolution, having evolved in only three lineages; the pterosaurs, birds, and bats. In avian species, the aerobic process of flying requires an efficient cardiovascular system that is capable of supplying the pectoral muscles with the proper amount of oxygen at different elevations and across a diverse suite of flight styles. In this study, avians were categorized as sedentary species (non-flying; e.g. rhea), imperfect fliers (short duration flight; e.g. tinamou), or sophisticated fliers (long duration flight; e.g. hummingbirds). Dissections of cardiac anatomy, structures of the heart, related vessels, and incorporated structures were conducted using species of birds within the imperfect and sophisticated flight categories. Sedentary species parameters were procured from the literature. High quality dissection photographs, estimated measurements of cardiac capabilities, and species-specific anatomical parameters were gathered to determine the cardiac output needed for sustained powered flight. We found that the hearts of birds are adequately evolved for maintaining a high level of cardiac output during powered flights in both imperfect and sophisticated fliers. We also found that heart size relative to body size correlates to improved flight capabilities by increasing the aerobic capabilities of birds across all flight styles. This data provides evidence which allows us to interpret the cardiac output required for different patterns and capabilities of powered

flight. Approaches to analyzing the capabilities and relative sizes of individual organs such as the heart used in this study will lead to more insight into the evolution of organ level mechanisms that help to regulate and facilitate locomotion in the evolution of flight in vertebrate organisms and birds in particular.

Funding Sources Albright Creative Research Experience

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

INITIAL COMPARISON OF THE AUDITORY MORPHOLOGY IN MODERN AND FOSSIL PINNIPEDS

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Overall, research has been extremely limited on the morphology, let alone associated function, of the auditory apparatuses of pinnipeds. These semiaquatic carnivorans include the modern Families of Phocidae (true seals), Otariidae (sea lions and fur seals), Odobenidae (walruses), and their extinct basal relatives. Pinnipeds are unique in possessing auditory adaptations that allow them to hear efficiently both in the water and on land. For mammals, this typically requires two separate auditory mechanisms. Currently, it is unknown how pinniped hearing works; many pinniped-specific adaptations have not been described due to inaccurate terminology of this region and the inability to correlate morphology to terrestrial taxa. The severe lack of information on this topic led to this initial study, comparing tympanic morphologies of modern and fossil semiaquatic carnivorans in relation to hearing. Modern representatives of Phocidae, Otariidae, Odobenidae, Ursidae (bears), and Mustelidae (weasels) were examined while fossil specimens included *Devinophoca claytoni*, *Devinophoca emryi*, *Puijila darwini*, *Hadrokirus martini*, *Pinnarctidion bishopi*, and *Eodesmus condonei*. Cranial measurements were used to calculate eleven ratios specific to the tympanic region and were included in a linear morphometric principal component analysis (PCA) to determine what areas of the auditory apparatus had the most significant variation in morphology. These ratios allowed for the exclusion of body size as a variable while still incorporating 'shape' without completing a geometric morphometric analysis. Fossil pinniped cranial material cannot always be used in geometric morphometric PCAs due to deformation. These ratios allow for distorted fossils to still be included in comparative analyses. This is the first study using this type of methodology, especially in reference to the hearing adaptations of pinnipeds. Results of the PCA exhibited distinct trends in modern phocid and fossil morphologies. Phocids tend to have overall larger tympanic bullar ratios and many of the fossil specimens plot similarly to terrestrial carnivores due to similar morphologies of the bony external acoustic meatus. These identified morphologies seem to

concur with current phylogenies and allow for isolation of adaptations specific to hearing. Once modern and fossil auditory morphologies are established, behavioral hearing analyses can also be incorporated to demonstrate the specific evolution of pinniped hearing.

Technical Session 5: Amphibians & Early Reptiles (Thursday, November 3, 2022, 8:00 AM)

ON THE HOMOLGY OF THE AMPHIBIAN 'ODONTOID PROCESS'

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The atlas-axis complex varies across tetrapods from being composed of many distinct components, as in alligators and tuatara, to highly fused, as in mammals, birds, and squamates. Among modern tetrapods, however, only amphibians entirely lack an axis so that a single cervical vertebra, the atlas, contributes to the skull–neck boundary. Interestingly, while documenting ossification sequences in the extant frog, *Xenopus laevis*, we noticed the periodic occurrence of a projection located between the atlantal cotyles of 15 out of 51 tadpole specimens spanning stages NF 58 to metamorphosis. This projection bears a striking resemblance to a feature that is generally thought of as unique to salamanders among extant amphibians – the interglenoid tubercle (i.t.), sometimes called an odontoid process.

Upon further investigation into i.t. occurrence and evolutionary history, we found that it is present at the base of each modern amphibian clade. The new data presented here reveal the i.t. persists much longer evolutionarily than previously thought, present in a modern frog's tadpole stages. A semiformal supertree analysis of dissorophoid temnospondyls shows axis loss followed by i.t. gain on the atlas occurring at the base of Lissamphibia. The tubercle is secondarily lost in extant caecilians and adult frogs.

Despite being shared between Lissamphibians, this feature is not unique to the clade. Certain 'microsaurs' possess an atlas that bears an 'odontoid process' very similar to the amphibian i.t. Prior to 'microsaurs' being reinterpreted as paraphyletic, this process was considered a synapomorphy of the group. No existing phylogenetic hypotheses support i.t. homology between 'microsaurs' and lissamphibians. However, these groups likely evolved along similar trajectories (e.g., miniaturizing), that resulted in numerous skeletal convergences. Due to the similarities between the atlanto-axial joint common in most tetrapods and the cranio-atlantal joint in tetrapods with an i.t., tubercle evolution in the latter may allow head rotation in taxa that have lost the axis. The secondary i.t. loss in adult frogs and caecilians is likely beneficial in reducing skull–neck boundary mobility during jumping and burrowing, respectively. Finally, the amphibian i.t. may be a

previously missed osteological synapomorphy of Lissamphibia, but the feature's occurrence in 'microsaurs' may indicate that the structure is another shared solution to the functional needs of small tetrapods.

Funding Sources NSERC RGPIN-06442

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

BIZARRE BACKBONES: A SYNAPOMORPHY IN THE LUMBAR VERTEBRAE FOR FERUNGULATA

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Mammals have a highly regionalized presacral spine, with constrained vertebral count controlled by development and ancestry. In contrast, individual vertebral morphology, especially within the lumbar region, appears to be evolutionarily labile, varying with locomotor style and body size. I looked at the fossil record to search for patterns of phylogenetic history underlying this variation. I used a combination of Paleogene fossils and modern specimens from across Mammalia to assess the phylogenetic history of lumbar morphology through the Cenozoic. I sample lumbar vertebrae from 57 mammals: 30 from a combination of extant and Neogene mammals, and 27 from Paleogene mammals. I developed qualitative characters to describe lumbar morphology to account for fossils with missing elements. I coded these 17 characters based on the morphology of the zygapophyses, transverse processes, neural spines, and centra. Specimens were accessed through the William R. Zooarchaeology Lab (WRAZL), descriptive papers, loans from University of Wyoming, and Morphosource.org. I mapped these characters onto a supertree of extinct and extant mammals using parsimony in the software Mesquite. I then calculated the retention indices for each character and the matrix as a whole. The retention index for all characters across the matrix was 0.369, indicating a high amount of homoplasy in this character set. Only three characters had a retention index (RI) of greater than 0.5: presence of xenarthran articulations (RI=1), presence of anapophyses (RI=0.667), and presence of a lamina on the dorsal edge of the postzygapophyses forming an S-shape in the frontal plane (RI=0.538). Xenarthran articulations are a well-known synapomorphy of Xenarthra and anapophyses are likely plesiomorphic to therian mammals. Among extant mammals, the S-shaped postzygapophysis is known only from Artiodactyla. However, this feature is found in many extinct Paleogene mammals, including hyaenodonts, oxyaenids, mesonychids, arctocyonids, and the stem perissodactyl *Cambaytherium*. This suggests that this character may be basal to Ferungulata and secondarily lost in Carnivora and crown Perissodactyla. Previous study has shown that these S-shaped zygapophyses prevent torsion between vertebrae. It is possible

this feature evolved in response to a need for stabilization in posterior spine as ribs became reduced.

Funding Sources Geological Society of America;
Galloway/Perry/Horowitz Memorial Fund

Regular Poster Session 1 (Wednesday, November 2, 2022,
4:30 - 6:30 PM)

**A LATERALLY EXTENSIVE AVIAN ROOKERY
FROM THE DELTA FACIES OF THE GREEN RIVER
FORMATION, SPANISH FORK CANYON, UTAH
COUNTY, UTAH**

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The Eocene deposits of the Green River Formation are internationally recognized and well documented for the preservation of vertebrate taxa. However, very little research has been published on eggs and nesting sites from this formation. Here, we present a preliminary report on a laterally extensive avian rookery in the Delta Facies of the Green River Formation in Spanish Fork Canyon of Utah County, Utah. The specimens occur in an orange-weathering micritic limestone that forms a prominent bench between gray mudstones typical of outcrops in the area. Thousands of centimeter-square fragments of eggshell, some potentially representing partial compressed eggs, occur in this ledge for at least 300 meters before the horizon is stratigraphically offset. Twenty-one accumulations of associated, partially articulated, and isolated avian bones associated with this eggshell have been noted in-situ. Tentatively, the avian bones are referred to *Presbyornis*, but more thorough preparation and fossil recovery need to occur to confirm this assessment. In association with these avian remains are isolated turtle shell fragments, crocodylian scutes, and planispiral gastropod impressions typical of the Green River Formation in the area.

It is hypothesized that this location represents a nesting area for a large seasonal group of wading birds on the margins of a lacustrine setting. The presence of abundant eggshell, as well as the disarticulated to associated nature of the bones indicates possible wave action, subaerial exposure, and other moderately energetic taphonomic modification prior to burial. The geologic setting and presence of crocodylian and turtle remains reinforce the marginal lacustrine nature of the depositional setting.

While *Presbyornis* bone and eggshell accumulations have been preliminarily reported from the Green River Formation, extensive taphonomic treatments of these locations have not been formally published. Our goal is to provide a detailed description of the taphonomic and stratigraphic setting of this location, comparison with other described Green River

Formation avian rookeries, and descriptions of the ootaxon and avian specimens preserved.

Colbert Prize Session

**A NEW ALVAREZSAURID FROM THE UPPER
CRETACEOUS OF MONGOLIA REVEALS A
TAXONOMIC DIVERSIFICATION AND AN
ADAPTATION FOR AGILITY OF ALVAREZSAURIDS**

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Alvarezsaurids, globally distributed during the Late Cretaceous, are gracile, small theropods with several avian homoplasies and specialized forelimbs. They diversified especially in the Gobi Desert of China and Mongolia, but little work has addressed the factors of this adaptive radiation because of poorly-resolved interrelationships of this group. Herein, we report a nearly complete alvarezsaurid skeleton from the Upper Cretaceous Baruungoyot Formation in the Nemegt Locality, Mongolia. This new Nemegt specimen is distinguished from other alvarezsaurids by three cranial characters (dorsoventrally high narial opening of the premaxilla, medially curved parasagittal crest on the parietal, slender and nearly straight dentaries), as well as four postcranial characters. Our phylogenetic analysis demonstrates that the new Nemegt specimen belongs to the derived clade of Alvarezsauridae, composed of (*Mononykus olecranus*+(new Nemegt specimen+*Shuvuuia deserti*)). Our well-resolved topology of alvarezsaurids further reveals that they diversified through habitat shifts from mesic to arid environments at least four times in the Nemegt Basin, Mongolia. In addition, vertebral compositions and hind limb proportions were modified drastically from the condition in basal alvarezsaurids. The dorsal counts decreased from thirteen in non-alvarezsaurid alvarezsauroids to less than ten in alvarezsaurids. On the other hand, the cervical and sacral counts increased from ten to twelve and five to seven, respectively towards the clade of alvarezsaurids, resulting in the reduction of the trunk region relative to the pelvis. The relative lower hindlimb length (tibia+metatarsal III or IV) also increased in alvarezsaurids. These modifications imply a high adaptation for agility, which is likely to be advantageous in both predator evasion and foraging efficiency in open and arid habitats with limited food resources.

Funding Sources JSPS 21J12938 (KK)

Technical Session 11: Synapsida (Friday, November 4, 2022, 8:00 AM)

ASSESSING AGE STRUCTURE IN A MULTITAXIC CYNODONT ASSEMBLAGE FROM THE MIDDLE TRIASSIC MANDA BEDS OF TANZANIA

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Eucynodonts are under-sampled histologically but were common components of paleocommunities during the much of the Triassic. Hundreds of disarticulated cynodont remains have been recovered from the Manda Beds of Tanzania, comprising both herbivorous and carnivorous taxa (i.e., *Scalenodon*, *Cricodon*, *Luangwa*, *Aleodon*, and *Cynognathus*), and permit the first assessment of life history and assemblage-wide age structure for these contemporary taxa. We thin-sectioned 32 individuals and measured the remaining femora and tibiae from seven penecontemporaneous sites.

Importantly, our histologic sample spans the entirety of size classes recovered and provides critical insight to determine whether large individuals have bone tissue compositions reflective of somatic maturity.

The histologic sample is largely characterized by immature bone tissue, with abundant primary vasculature in a mosaic of woven and parallel-fibered matrix. *Scalenodon* and *Aleodon* hindlimbs are composed of variable amounts of compact coarse cancellous bone (CCCB) in the deepest cortex, occasionally bounded by a reversal line of organized endosteal tissue, followed by highly vascularized primary tissue. In some individuals, highly vascularized tissue is continuous throughout the cortex, suggesting that individuals died at immature ontogenetic stages. Other elements record a shift from woven/parallel-fibered bone matrix to lamellar tissue along the subperiosteal edge, indicating a potential plateau or pause in growth. One partial femur tentatively referred to *Scalenodon*, preserves a well-defined external fundamental system (EFS), despite coming from an element at ~75% maximum size. To our knowledge, this is the first EFS reported for a cynodont and highlights the need for widespread histological sampling to accurately characterize the growth dynamics and life histories of nonmammalian cynodonts.

Taken together, our results indicate that the Manda cynodont assemblage records juveniles and subadults, with rare instances of somatically mature individuals. Within immature size classes, there is histo-variability in the amount of parallel-fibered and lamellar bone. Finally, the inferred age structure suggests that either the fossil-bearing localities of the Manda Beds preferentially preserve areas where immature cynodonts aggregated in large numbers, or that high rates of mortality among immature individuals were commonplace during Manda deposition.

Funding Sources NSF EAR-1337569

Technical Session 18: Birds (Saturday, November 5, 2022, 1:45 PM)

EVOLUTIONARY HISTORY OF BIRD MORPHOLOGY: USING 3D SCANS TO ESTIMATE ANCESTRAL STATES OF GALLOANSERAN QUADRATES

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In birds and other reptiles, the quadrate acts as a hinge connecting the lower jaw with the cranium and plays an important role in avian cranial kinesis. Although previous studies have qualitatively described the quadrate's substantial morphological variability, none have tried to quantify evolutionary changes in its shape. Here, we investigate shape changes of the quadrate in Galloanserae, a major clade of extant birds uniting relatives of living chickens (Galliformes) and ducks (Anseriformes). We quantified morphological variation in the quadrate across 50 extant galloanseran taxa covering all major extant subclades using three-dimensional geometric morphometrics, and performed ancestral shape reconstructions in the context of an up-to-date neornithine phylogeny. We show that Galliformes and Anseriformes occupy distinct regions of morphospace, whereas Anhimidae plot in a different region from other anseriforms. We also find that ancestral state reconstructions based only on extant quadrates fail to recover plesiomorphic features observed in stem group taxa. Therefore, where possible, we strongly encourage the addition of fossil taxa into geometric datasets for ancestral state reconstructions. After incorporating the morphological variation exhibited by early fossil galloanseran quadrates (*Asteriornis*, *Presbyornis*, and *Conflicto*), our reconstructed ancestral galloanseran quadrate approximates aspects of quadrate morphology observed in galliforms, indicating that the ancestor of Galloanserae might have been similar to many extant galliforms in the morphology and function of its quadrate. Our reconstructed models do not closely resemble the quadrate of *Dasornis*, suggesting that the enigmatic pelagornithids exhibited a quadrate specialised for functions outside the range of those exhibited by other known galloanseran taxa. We hope our approach will help elucidate important aspects of the morphology and function of the feeding apparatus of early crown birds.

Funding Sources UKRI Future Leaders Fellowship MR/S032177/1, Royal Society Research Grant RGS/R2/192390, and the Palaeontographical Society Richard Owen Research Fund

Virtual Posters

ECOLOGICAL NICHE OF *HERPETOCETUS* (CETACEA, MYSTICETI) REVEALED FROM FUNCTIONAL MORPHOLOGY

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Herpetocetus belongs in the family Cetotheriidae, one of the extinct groups of baleen whales that are closely related to the Balaenopteriidae. It is widely known from the late Miocene to the Pliocene (or until the middle Pleistocene) of the Northern Hemisphere. The phylogenetic relationship of *Herpetocetus* in the Cetotheriidae within the Mysticeti has recently become better understood, and some researchers have advocated that *Herpetocetus* is most closely related to the Southern Hemisphere enigmatic mysticete, the pygmy right whale (*Caperea marginata*). By contrast, their enigmatic characters have not been well documented, such as a very small body size (3–4 m in length) and a unique morphology of the mandible, which are not known in other mysticetes. Nevertheless, little has been done on the study of behavioral ecology for this enigmatic mysticete. Hence, the purpose of this study is to unveil the mysterious ecology of *Herpetocetus* on the basis of the functional morphology and morphometrics. Then, a potentially unique ecological niche of *Herpetocetus* is considered based on the relationship between their habitat and adaptive evolution. We used the nearly complete skeleton of *Herpetocetus sendaicus* collected from the lower Pliocene Tatsunokuchi Formation, which bears a registration number NMNS-PV 19540. We measured the width of the bizygomatic arch of the skull of NMNS-PV 19540 to infer the whole body length, and we also measured the length, width and height of centrum of vertebrae to reconstruct the swimming mode related to its behavioral ecology. As a result, we found that *Herpetocetus sendaicus* represented by NMNS-PV 19540 was a very small mysticete with an estimated body length of about 3 m. This is consistent with previous studies on other species of this genus. In addition, *Herpetocetus* has a swimming mode similar to the odontocetes, because the shape of the vertebrae of *Herpetocetus* fell into the category of delphinids (e.g., *Monodon monoceros* and *Delphinapterus leucas*) that swim at relatively high speeds. Moreover, the feeding strategy of *Herpetocetus* was clearly different from those of the modern mysticetes, at least of the balaenopteroids and balaenoids. Consequently, it suggests that *Herpetocetus* has an ecology and ecological niche different from those of modern mysticetes. In this regard, it will be very important to compare with *Caperea marginata*, which is also a small mysticete of about 5m and its behavioral ecology is not well known to date.

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

TAPHONOMY AND ICHNOLOGY OF NILE CROCODILE FEEDING BEHAVIOR

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Crocodylians employ unique feeding behaviors as compared to other predators in modern environments. Large crocodiles use immense jaw strength coupled with inertial and rotational force to consume large fauna with relative ease. Given the unique forces applied to crocodile modified carcasses, we would expect to find equally unique traces of such feeding behaviors on any uningested skeletal remains of their prey. Here we examine bone surface modification produced by Nile crocodiles (*Crocodylus niloticus*) in controlled feeding experiments. We define the crocodile feeding traces observed in our experiment as ichnotaxa. Using these ichnotaxa, we then describe patterns of bone surface modification that appear to reflect various observed feeding behaviors. Traces which indicate sudden changes in force direction we relate to the carcass disarticulation techniques utilized by crocodiles such as shaking and death rolling. Pairs of mechanically equivalent traces are observed at distances equivalent to crocodile tooth spacing. Pairs of nearly identical traces, parallel and in close proximity to each other, are correlated to a rapid succession of bites, a characteristic of non-masticatory feeding. We document these traces through quantitative and qualitative means, evaluating occurrence, patterning, and individual morphology using direct measurement and digital surface scanning. With compounding paleontological evidence, these traces could be a robust indicator of crocodile ecology in the fossil record.

Technical Session 3: Marine Reptiles (Wednesday, November 2, 2022, 8:00 AM)

QUANTIFYING THE EARLY ECOMORPHOLOGICAL DIVERSIFICATION OF EOSAUROPTERYGIA

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The Triassic biotic recovery following the end-Permian mass extinction is marked by a rapid radiation of reptiles secondarily adapted to marine environments. The diversification of Eosauropterygia, the most speciose clade of marine reptiles, is a key part of that rise to dominance of aquatic reptiles. Recent studies of eosauropterygian disparity through the Mesozoic highlighted that the greatest extent of morphological diversity was recorded during the Middle Triassic. This period indeed sees the co-occurrence of numerous species with various body-size ranges, diets, and

swimming modes: pachypleurosaurs, nothosaurs and pistosaurs, mostly in the Tethys Ocean. However, these broad-brush studies have focussed their investigations on the shape of mandible and teeth, thus leaving out a significant portion of skeleton. As a result, our understanding of the disparity of Triassic eosauroptrygians and how it has fluctuated between groups is limited. To tackle this issue, we reinvestigated and quantified morphological diversification of long-bodied Triassic eosauroptrygians. We erected 32 biomechanically-informative traits on teeth, mandible, limbs, and axial skeleton for 142 specimens spread over 36 species belonging to Pachypleurosauroidea, Nothosauroida and Pistosauroida. We submitted our trait data to ordination methods to recreate the evolution of morphospace occupation by Triassic eosauroptrygians. Our multivariate analyses highlight clear ecomorphological differences between these three clades, with no evidence for important whole-body convergent evolution. This morphological distinction is however stronger in cranial rather than in postcranial anatomy: postcranial anatomy morphospace recovers nothosaurs and pistosaurs as distinct but pachypleurosaurs slightly overlaps with the two former groups. This suggests a decoupling in the morphological evolution of these two regions, similar to what has proposed for derived, short-necked plesiosaurians.

Funding Sources Fond de la Recherche Scientifique doctoral (F.R.S– FNRS), FRIA grant (FC38761) for AL

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

ADDITIONAL POST-CRANIAL MATERIAL AND THE DISCOVERY SITE OF THE ERPETOSUCHID *PAGOSVENATOR CANDELARIENSIS*, FROM THE MIDDLE-LATE TRIASSIC OF BRAZIL.

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The intense fieldwork on the Triassic outcrops of the *Dinodontosaurus* Assemblage Zone (AZ), Pinheiros-Chiniqua Sequence (latest Ladinian-earliest Carnian) of the Santa Maria Supersequence, State of Rio Grande do Sul (RS), southern Brazil, have uncovered many new fossil taxa, elucidating a previously underestimated faunal diversity. However, the accidental discoveries in some municipalities made by locals have also contributed to this progress. One such case is the holotype of *Pagosvenator candelariensis*, an erpetosuchid, composed of a complete skull, three cervical vertebrae and some rectangular and ornamented osteoderms. It was deposited at the Museu Municipal Aristides Carlos Rodrigues in Candelária, and, unfortunately, was without any collection information. The local media interest after its publication produced a larger interest on this fossil in the local

communities, which produced interesting results. The first is the identification of its original precedence site, a yet unnamed new outcrop at one of the curves of the Plumbs stream, located between the municipalities of Vale do Sol and Veracruz, RS. Preliminary fieldwork on this site has uncovered an assortment of fossils, which include isolated osteoderms morphologically similar to *P. candelariensis* and an isolated maxilla bearing a tusk of a *Dinodontosaurus* sp., which confirms the assemblage zone designation originally identified in the original work by use of Rare Earth element analysis. The second new information is of an additional part of the holotype, originally removed during the collection, and is now being studied. This material consists of eight articulated cervical vertebrae, several complete and broken cervical ribs and at least six rectangular and ornamented osteoderms of varying sizes, the largest with 5x4 cm. These new discoveries will further help to understand this complicated specimen and its environment, but also is an additional example of the importance of scientific outreach and the resulting collaborative effort in local communities where the fossil discoveries occur.

Funding Sources ML and MBS are supported by a grant from the Fundação de Amparo à Pesquisa do Estado do Rio de Janeiro (FAPERJ process number E_25/2021P10).

Technical Session 19: Marine Mammals (Saturday, November 5, 2022, 1:45 PM)

TRANSFORMING FOSSIL DIAGENESIS FROM A PROBLEM INTO A TOOL: MICROTAPHONOMIC FEATURES OF BONE REFLECT EARLY DEPOSITIONAL ENVIRONMENTS AND THUS THE DYNAMICS OF TIME-AVERAGING IN MIOCENE (CALVERT CLIFFS, MD) AND EOCENE (VALLEY OF THE WHALES, EGYPT) MARINE SILICICLASTIC RECORDS

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Although bonebeds are a rich record of vertebrate remains, they can reflect complicated overprinting by time-averaging processes such as erosional winnowing or prolonged exposure before permanent burial, with potential to affect the original biologic signal. Microtaphonomic and diagenetic features such as microboring, staining, cracking, and authigenic infills, which are often rarely considered, could provide a valuable additional means of recognizing taphonomically complex histories: bones are most reactive during their immediate post-mortem window and should thus acquire microscopic evidence of those environmental conditions. Bones from rapidly deposited sediments (minimal time averaging) should exhibit little alteration, as they've experienced comparatively brief opportunities for bioerosion, biogeochemical interactions in the taphonomically active zone, and other processes; bones from erosional settings have potential for overprinting by

oxidized minerals and for evidence of drying and/or abrasion related to reworking and subaerial exposure; and bones from sediment-starved or other hiatal settings (delayed burial) should reflect the maximum opportunity for alteration, with heavily tunneled bone margins and complex infilling minerals related to redox cycling in the surface mixed layer. To test this hypothesis, cetacean bones were sampled from two well-known Cenozoic marine records where the duration of pre-burial conditions can be estimated from an already-established sequence stratigraphic context, and bones are known to display variable macroscopic preservation. Bones from the unlithified Miocene strata of the Calvert Cliffs do preserve diverse features consistent with their expected early depositional environment, such as both marine and terrestrial forms of microboring, microcracks from both swelling and drying, and varied degrees and compositions of infilling. Bones from the lithified Eocene strata of the Valley of the Whales are densely infilled with authigenic minerals, but still distinguish disparate pre-burial conditions via both microtaphonomic features and carbonate microfacies. Microtaphonomic and authigenic alteration of bones thus captures the early diagenetic, pre-burial conditions of bone accumulation in marine settings, correlative with the predicted duration of time averaging and persisting despite pervasive late diagenesis and weathering. Such features thus represent a valuable tool to understanding the nature of bone assemblages.

Funding Sources Funded by the Paleontological Society, Society for Sedimentary Geology, Geological Society of America, and the University of Chicago Department of Geophysical Sciences.

Virtual Posters

THE EVOLUTION OF BEAKS IN THE PERMIAN AND TRIASSIC

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Beaks are compound oral structures that are present in extant birds and turtles, yet they were more widespread in the past, arising independently in multiple clades during the Permian and Triassic. Here, we explore beak evolution through the end-Permian crisis, and during the resulting recovery and diversification of feeding ecology among archosauromorphs and synapsids in the Triassic. We examine dicynodonts, rhynchosaurs, allokotosaurs, aetosaurs, poposauroids and basal dinosauriforms, following the evolution of vertebrate beaks, from their first documented appearance in dicynodonts of the Middle Permian to their widespread adoption by multiple clades in the aftermath of the end-Permian extinction. The beaks of birds and turtles are associated with toothlessness and a rhamphotheca (the corneous beak cover) that envelops the premaxilla, maxillae, and dentaries. However, Permian and Triassic tetrapods sometimes had oral

structures that retained teeth as well as a modest corneous covering. We quantified key features of the jaws, teeth, and bony beaks of the Permian-Triassic clades with linear measurements of crucial functional traits, including the reconstructed position of the corneous covering and inferred insertion points for the jaw musculature. We capture the overall shape variation of the mandibles via an elliptical Fourier analysis and that of the beaked portion of both jaws using a two-dimensional semi-landmark analysis. We also use multivariate approaches to quantify variation in functionally relevant traits, such as mechanical advantage, articular offset and symphyseal deflection. Our results show that Permian-Triassic beaked clades occupied well-separated areas of the morphospace, implying that they avoided competing for the same sources of food by specializing in distinct niches. Dicynodonts occupy a specialized niche with sturdy and powerful jaws that are well-suited for shearing food. After the end-Permian mass extinction, the surviving dicynodonts recovered from the ecological disaster by diversifying their beaked jaws into bulkier and larger forms. This condition was then magnified by the last surviving dicynodonts, the kannemeyeriids. Triassic dicynodonts, however, expressed a narrower morphological and functional range than their Permian ancestors.

Technical Session 16: Hoofed Mammals (Saturday, November 5, 2022, 8:00 AM)

INVESTIGATING THE RELIABILITY OF METAPODIALS AS TAXONOMIC INDICATORS FOR BERINGIAN HORSES

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The metapodials of extinct horses have long been regarded as one of the most useful skeletal elements for determining taxonomic identity. However, recent research on both extant and extinct species of *Equus* has revealed plasticity in metapodial morphology, leading to notable variability within and among taxa. This calls into question the reliability of metapodials in species identification, particularly for species identified from fragmentary remains. Here, we use ten measurements of metapodials from 136 specimens of four named Pleistocene horse species and 67 specimens that were not identified to the species level (referred to as *Equus* sp.) from eastern Beringia to test whether there are significant differences in metapodial morphology that would support the presence of multiple species. We then generate body mass reconstructions to assess the range in body size within each named species. We find that taxonomic groups are based largely on the overall size of the metapodial, as all metapodial measurements are highly autocorrelated, and there exists continuous variation in metapodial size among species groups. We also find that mean body mass differs significantly among most, but not all, named species. We suggest that metapodial

measurements are unreliable taxonomic indicators for Beringian horses given considerable potential for within-species variability in metapodial morphology. We recommend future studies use more reliable indicators of taxonomy to identify Beringian horse species, particularly from localities from which fossils of several named species have been recovered.

Funding Sources This work was supported by a Canadian Museum of Nature Research Activity Grant and a NSERC Discovery Grant (RGPIN-2018-05305) awarded to Danielle Fraser.

Technical Session 8: Evolutionary Developmental Biology
(Thursday, November 3, 2022, 1:45 PM)

THE WAY TO WONKINESS: THE ONTOGENY OF ASYMMETRY IN ECHOLOCATING WHALES

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Extreme asymmetry of the skull is one of the most distinctive traits that characterizes toothed whales (Odontoceti, Cetacea). Fossil evidence shows that this trait has emerged multiple times in the evolutionary history of Cetacea, appearing first in the rostrum of the extinct Archaeoceti and completely disappearing in modern baleen whales (Mysticeti). Its origin and function in Odontoceti are connected to the evolution of underwater hearing and echolocation, the ability to use high frequency sounds to navigate the surrounding environment. Although this novel phenotype must arise through changes in cranial development, the ontogeny of cetacean asymmetry has never been investigated. Here we use three-dimensional geometric morphometric to quantify the changes in degree of asymmetry and skull shape during development from early fetal to adult stages for five genera spanning odontocete diversity (oceanic dolphins, porpoises, and beluga), each with a unique set of ecological adaptations. Our dataset includes a total of 58 specimens digitized using both CT and surface scanning methods. We placed 462 landmarks and semilandmarks and conducted statistical analyses in R to quantify the change in asymmetry level at different ontogenetic stages, as well as the variation in skull shape and size during development. We found that cranial asymmetry developmental patterns are heavily influenced by ecology and echolocating frequencies. Asymmetry in early ontogeny starts low and tracks phylogenetic relatedness of taxa. Distantly-related taxa that share aspects of their ecology, including feeding habit, sociality, and range of broad-band hearing frequencies, overwrite these initial differences via heterochronic shifts, ultimately converging on comparable high levels of skull asymmetry. Porpoises maintain low levels

of asymmetry from the early fetal stages through to adults and present a decelerated rate of growth in the shape and size of the skull, likely retained from the ancestral condition and facilitating specialized narrow-band high frequency hearing in these taxa. Ancestral state reconstruction of allometric trajectories demonstrates that both paedomorphism and paramorphism contribute to cranial shape diversity across odontocetes. This study provides a striking example of how divergent developmental pathways can produce convergent ecological adaptations and corroborates hypotheses on the pattern of skull asymmetry evolution based on fossil data.

Funding Sources European Commission Marie Skłodowska-Curie IF “Evo-Devo-Whales” (project number: 894584) to A.L.; NERC DTP training (grant number: NE/L002485/1) to E.J.C..

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

A NEW HELOCHELYDRID TURTLE (HELOCHELYDRIDAE; TESTUDINATA) FROM THE LATE CRETACEOUS OF BRITISH COLUMBIA, CANADA

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We report a new helochelydrid turtle from the Late Cretaceous Haslam Formation of Vancouver Island, British Columbia, Canada. The specimen is represented by paired hyo-, meso-, hypo-, and xiphial elements, two neural elements, five right and three left costal plates, seven free peripherals, and six bridging peripherals. A partial suprapygal and entoplastron may be present, but their morphology is mostly not preserved. The specimen is typical for helochelydrids in its distinct shell ornamentation that consists of distinct tubercles, particularly *Naomichelys speciosa*, *Helochelydra nopscai*, and *Helochelys danubina*, which are characterized by surface shell ornamentation with high tubercles that are easily dislocated. The new specimen differs from *Naomichelys* in several features. The lateral margins of the hyoplastra sweep anteriorly, making the hyoplastron-epiplastron sutural contacts bow posterolaterally. The entoplastron appears to have been very wide, making the hyoplastron-epiplastron contact less than half the length of the hyoplastron-entoplastron contact. The posterior plastral lobe is more tapered than the broadly rounded lobe of *Naomichelys speciosa*. The specimen also appears to lack a plastral fontanelle. Similar to *Naomichelys*, the marginal scutes completely cover the peripherals. With an age of ~81.0 Ma, this specimen is one of the youngest helochelydrid specimens known from North America, and is comparable to more fragmentary material from the Milk River

(83.5 Ma) and Foremost (78.5 Ma) formations of southern Alberta. Together, the Haslam specimen and the Alberta material represent some of the last known helochelydrids in North America.

Funding Sources This work is supported by the Royal BC Museum.

Technical Session 2: Paleoecology (Wednesday, November 2, 2022, 8:00 AM)

DISRUPTION OF TRAIT-ENVIRONMENT RELATIONSHIPS IN AFRICAN MEGAFUNA COINCIDENT WITH HOMININ EMERGENCE

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Mammalian megafauna have been critical to the functioning of Earth's biosphere for millions of years. However, since the late Miocene, their biodiversity has declined, concurrent with dramatic changes in global climate and the expansion of hominin influences. Many studies have evaluated the relative roles of climate and hominins in driving megafaunal decline with conflicting results. Here, we reframe this issue by adapting traditional ecometric methods to evaluate the timing of disruptions in the trait-environment relationships of herbivorous, eastern African megafauna over the past 7.5 Ma. We assessed temporal patterns in herbivore biodiversity, as well as the consistency of community trait-environment relationships, across concurrent environmental and biotic changes. Herbivore functional diversity began declining once grasslands became dominant ~5 Mya, whereas taxonomic and phylogenetic diversity declined once *Homo erectus* emerged ~1.9 Mya. Following *Homo erectus*' emergence, the trait-environment relationships of herbivore communities shifted significantly. Thus, although both climate-mediated and hominin events coincided with megafaunal diversity losses, only the hominin fossil record corresponded with losses in which the ecological function of megafaunal communities was threatened. Climate-mediated change, conversely, associated with diversity losses occurring as the megafaunal trait pool narrowed towards traits adapted to grassland environments.

Colbert Prize Session

MAMMALIAN EVOLUTION IN RESPONSE TO CLIMACTIC AND TECTONIC DRIVERS AT THE EOCENE-OLIGOCENE BOUNDARY IN THE VALLEY OF LAKES, MONGOLIA

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Throughout the mid-Cenozoic, global climate change alongside uplift of the Tibetan Plateau and surrounding mountain ranges led to the aridification of much of what is now Mongolia. At this time, a mammalian faunal change termed the Eocene-Oligocene Mongolian Faunal Turnover occurred, resulting in morphological and ecological changeover in tandem with environmental aridification. It has been found during this time that taxa such as perissodactyls, more suited for browser rich environments, were replaced by rodents and lagomorphs that were thought to be better ecologically suited for the arid grasslands of the Oligocene. Because of this, we expect to see an increase in hypsodonty and a changeover in taxa towards the clades found to be more suited for an arid environment. We examine sites from the Eocene to the Oligocene in Mongolia and obtained taxonomic and occurrence data from the Paleobiology Database and used published literature to discern body mass estimates and tooth height indices. In rodents and lagomorphs, this data suggests an increase in hypsodonty and richness through the Eocene-Oligocene, whereas ungulates undergo an increase in hypsodonty without a corresponding increase in richness. Body mass analysis suggests that the Eocene had generally larger body sizes, whereas the Oligocene had a reduced number of medium-sized taxa. Lagomorphs were an exception to this trend, with body masses decreasing significantly in the Oligocene. This study supports the previously observed Eocene-Oligocene Mongolian Turnover event and points to aridification, climate change, and complex geographic changes as driving factors. The profound changes in richness and morphology from the Eocene to the Oligocene support this study's hypothesis that hypsodonty and small mammal richness will increase alongside dynamic changes to the environment during this time of the Cenozoic.

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

AT THE CUTTING EDGE: STRUCTURAL AND ELEMENTAL COMPLEXITY OF ZIPHODONT TOOTH ENAMEL IN EXTANT AND FOSSIL REPTILES

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Serrated, blade-shaped (ziphodont) teeth have evolved multiple times within Amniota, but they are mostly restricted to extinct taxa, including theropod dinosaurs. Given the prevalence of ziphodont teeth in the fossil record, our ability to test their mechanical properties would therefore benefit from sound understanding of the structural and chemical changes to fossilized dental tissues, as well as tissue-level comparisons with analogous teeth in extant reptiles. Here we present structural, chemical, and nanomechanical analyses of the enamel and dentine of the teeth of Komodo dragons (*Varanus komodoensis*) and four species of extant crocodylians (*Alligator mississippiensis*, *Crocodylus porosus*, *Tomistoma schlegelii*, *Osteolaemus tetraspis*); we then compare these with fossil tyrannosaurid and crocodylian teeth from the Late Cretaceous of Southern Alberta. Synchrotron X-ray Fluorescence (SXRF) spectroscopy reveals that the serrations of *V. komodoensis* and the carinae of at least some crocodylian species are coated with an iron- and zinc-rich layer of enamel. This coating produces orange-coloured serrations and tooth tips in developing and functional teeth of *V. komodoensis*, and of the carinae of two of the studied crocodylians. Nanoindentation reveals that the enamel and dentine in these reptiles have comparable mechanical properties to mammal teeth tissues. We hypothesize that this thin pigmented layer along the cutting edges increases their resilience, analogous to iron pigmentation in the enamel of many mammal teeth, and to metal inclusions in the mandibles of many arthropods.

We also investigated enamel structure and chemistry in tyrannosaurid teeth. Scanning electron microscopy and synchrotron X-ray microdiffraction revealed that, unlike in *V. komodoensis*, tyrannosaurid enamel structure varies along the serrations and throughout the crown, with the serration enamel more closely resembling the wavy enamel found in some herbivorous dinosaurs. However, elemental and nanoindentation analyses showed that the dental tissues have undergone significant diagenetic alteration and cannot be directly compared to assess structure-function relationships. SXRF analysis confirmed anomalous distributions of trace elements within the enamel and dentine of tyrannosaurid teeth. By comparing these results with similar data from fossil and extant crocodylian teeth, we evaluate the possibility that tyrannosaurid teeth had pigmented tooth tips, similar to some extant reptiles.

Funding Sources Horizon 2020 Marie Skłodowska Curie Fellowship, project “ENEVOLVE”

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

CHANGES IN CENTRAL TEXAS LIZARD DIVERSITY FROM HALL'S CAVE DURING THE LATE PLEISTOCENE AND THE HOLOCENE

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Herpetofauna play important roles in modern ecosystems; unfortunately, many living amphibians and reptiles are experiencing declines in biodiversity worldwide. The study of Quaternary fossils has the potential to guide and aid conservation strategies by granting insight into how past biota responded to environmental changes over long timescales. We use fossils from Hall's Cave, located in Kerr County, Texas, to reveal changes in lizard diversity in Central Texas over the last 20,000 years. We employed an apomorphy-based identification framework, using evolutionary derived features to provide strong evidence for fossil identifications at the genus level or higher. We cataloged and described over 3,000 fossil lizard specimens and in doing so added several taxa not previously known from the site. We examined lizard community composition through time and found that at the family level there have been substantial changes in the lizard community over time. Specifically, we recover relatively low Shannon diversity index values between four and five thousand years ago, between nine and ten thousand years ago, and prior to fourteen thousand years ago. The change in lizard diversity at the family level appears to be temporally correlated with changes in vegetation in the area surrounding Hall's Cave based on previously published pollen records including the transition from woodland dominated vegetation to increasingly open grassland habitat. Our results demonstrate the utility of the fossil record for extending our temporal study interval, and serving as a superb system for furthering our understanding of organisms' ecological and evolutionary responses to environmental changes.

Technical Session 5: Amphibians & Early Reptiles (Thursday, November 3, 2022, 8:00 AM)

WALKING ON EGGSHELLS: REEVALUATING THE 'HARD/SOFT' DICHOTOMY OF REPTILE EGGSHELL MICROSTRUCTURE IN A PHYLOGENETIC CONTEXT

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The eggshell of reptiles ensures water and gas exchange during incubation, and plays a key role in their reproductive success. Many clade-specific adaptations of eggshell microstructure have been associated with incubation and life history strategies in extant (birds, crocodylians, turtles, and lepidosaurs) and extinct taxa (e.g. non-avian dinosaurs). Traditionally, this structural diversity has been grouped into two main types: 'hard' and 'soft' – sometimes with a third

intermediate category, 'semi-rigid'. In recent years, however, debate over the evolution of eggshell structure in major reptile clades (e.g. Archosauria, Dinosauria) has revealed how definitions of hard and soft eggshells influence inferred deep-time evolutionary patterns. Here, we provide an overview of eggshell diversity in major reptile clades, and the criteria that have been used to define hard, soft, and semi-rigid eggshells. We show that all scoring approaches that retain these categories discretize continuous quantitative traits (e.g. eggshell thickness) and do not consider independent variation of other functionally-important microstructural traits (e.g. degree of calcification, shell unit inner structure). We demonstrate the effect of various approaches to discretizing eggshell type into hard, semi-rigid, and soft using ancestral state reconstructions for 200+ species representing all major extant and extinct reptile clades. These approaches recover different ancestral states for all major clades including Archosauria and Dinosauria, despite a difference in scoring for only 1–4% of the sample. Proposed scenarios of reptile eggshell evolution are highly conditioned by sampling, tree calibration, and lack of congruence between definitions of eggshell type. We conclude that the traditional 'soft/hard/semi-rigid' classification of reptilian eggshells is misleading, and provide guidelines for future descriptions focusing on specific functionally-relevant characteristics (e.g. inner structures of shell units, pores, and membrane elements), analyses of these traits in a phylogenetic context, and sampling of previously undescribed taxa, including fossil eggs.

Funding Sources This study was supported by the Howard Hughes Medical Institute (GT10473, JAC and LJL) and the National Research Foundation of Korea (2020R1A6A3A03038316, SC).

Technical Session 5: Amphibians & Early Reptiles (Thursday, November 3, 2022, 8:00 AM)

PANCAKE FROG IN THE BOG: CHRONOLOGY AND PALEOBIOGEOGRAPHY OF PIPIDAE (ANURA) DIVERSIFICATION

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Pipids possess one of the best fossil record among anurans, starting during the mid-Cretaceous. Although several occurrences are known in Europe, Pipidae diversified in Gondwana (Africa and South America), where their extant representatives still live. This diversification has traditionally been dated to lower Late Cretaceous, likely linked to the final opening of the Atlantic Ocean. However, several uncertainties persist on the chronology of the diversification around the Early/ Late Cretaceous boundary. The study of this diversification is based on a novel phylogenetical approach. This approach combines detailed stratigraphic data and the "Fossilized Birth-Death Process" (FBD) model of

diversification and fossilization. This method produces density probabilities of divergence time for each node within the phylogenetic tree. Our analyses suggest that Pipidae emerged between the Aptian (Early Cretaceous) and the Cenomanian (Late Cretaceous), between 126 and 95 million years ago, depending on the topology used and the attribution of several fossils to *Pachycentrata taqueti*. This result is compatible with molecular analyses. Our results suggest an intense evolutionary radiation of Pipidae during the 10 million years that followed its origin. This radiation yielded numerous south American and African taxa during the Late Cretaceous and Paleogene. This radiation also indicates that a terrestrial link between Africa and South America was maintained until the end of the Cenomanian. Furthermore, these results suggest long ghost lineages for some extant pipid lineages (including those of *Pipa* and *Hymenochirus*), some of which originated during the Cretaceous.

Funding Sources Grant from the Fondation pour la Recherche sur la Biodiversité (FRB, France) to Alfred Lemierre

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

THE CEPHALIC LATERAL LINE SYSTEM OF MARINE TETRAPODOMORPHS FROM THE MIDDLE DEVONIAN, RED HILL, NEVADA

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The Red Hill locality of Nevada from the Middle Devonian (late Givetian) has produced tetrapodomorph fossil specimens, originally thought to all belong to a single taxon, *Eusthenopteron foordi* (or *E. gregorii* in an unpublished thesis). However, their taxonomic assignment has been revised to *Tinirau clackae*, an elpistostegalian. A latter study has suggested that some of those fossils should be assigned to another tetrapodomorph species, *Bruehnopteron murphyi*, a tristichopterid. Upon studying the lateral line canal systems of early osteichthyes from Red Hill, we reexamined the tetrapodomorph skulls deposited in the collection of University of California, Museum of Paleontology (UCMP 117884, 118283, 118605, 190999, 123135, 190998). Although the supraorbital, infraorbital, and preopercular canals are present in all the skull roofs, variations in sensory canal and pitline morphology suggest there were likely two species, of which UCMP 117884 and 118283 belong to *B. murphyi*, whereas UCMP 118605 and 190999 belong to *T. clackae*. The two parieto-ethmoidal shields of *B. murphyi* have canal openings at the intertemporal and premaxilla with minimal pit lines on both sides of the parietal. In contrast, *T. clackae* lacks visible pores, but shows sensory canal grooves along the dermal bone. Furthermore, the cephalic sensory canal system of *B. murphyi* shows ontogenetic change. The smaller

specimen (UCMP 118232, 34 mm in the Length of Parieto-Ethmoidal Shield – LPE, from anterior end of premaxilla to posterior edge of the parietal along the midline) has visible canal pores on the dermal surface, outlining the transition of the infraorbital to the supraorbital canals medially at the premaxilla; whereas the larger specimen (UCMP 117884, 128 mm in LPE) shows no signs of any supraorbital and infraorbital-associated canal pores. This ontogenetic pattern is not seen in *T. clackae* specimens (UCMP 118605 estimated LPE 121-139 mm, and UCMP 190999 LPE 109 mm), which instead show consistent pit line morphologies. This preliminary study suggests that ontogenetic change in the sensory canal is probably a distinctive feature in some tristichopterids, which is pending further examination on more tristichopterid species. In addition, high-resolution CT imaging will be required to determine whether sensory canals were completely enclosed within the bone and if additional dermal bone growth conceals the pores in *B. murphyi*.

Symposium: International Community Connections
(Wednesday, November 2, 2022, 1:45 PM)

ASSESSING THE IMPACT OF INCLUSIVE DESIGN EDUCATION IN PALEOBIOLOGY COLLEGE COURSES

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Research has shown that more inclusive environments produce more creative science and more positive learning outcomes. We developed a project to test the hypothesis that teaching undergraduate students how to use concepts of inclusive design in their class assignments would increase their awareness of and appreciation for disability accessibility, thereby increasing accessibility for all.

During fall 2020, we designed and implemented a 6-week-long digital media project in an online, undergraduate non-majors human biology course with strong paleontology and paleoanthropology frameworks. The curriculum was then implemented during spring 2022 in three additional paleobiology-centered courses. Students produced a digital product – a video, podcast, or series of curated social media posts – that explained aspects of a peer-reviewed scientific article related to the course material. In addition to their broader science communication goals, students incorporated aspects of inclusive design, such as closed captioning for d/Deaf and Hard of Hearing audiences, audio narration for blind or low vision audiences, colorblind accessible palettes, or alt text for social media posts. Students were provided with pedagogical scaffolding throughout.

From the 2020 post-course Likert-scale reflections (N=336),

over 96% of students responded they agreed that they had “grown in [their] awareness of disability and accessibility accommodation”, and 93.8% “now consider disability to be a part of human diversity more than before this project or course”. In addition, 85.5% of student respondents shared that they agreed with the statement, “as a student, I feel more included in science because of this project or course.” Preliminary analysis of spring 2022 data indicates that 93.4% of students (N=106) agreed they had grown in disability awareness and accessibility accommodation, while 87.7% of students agreed that they considered disability to be part of human diversity more than before the project. A key component of this work involved mixed method analysis, where qualitative thematic analysis of text was used to inform the quantitative process.

Using digital media projects that incorporate inclusive design, we can help more students feel welcome in STEM fields. Ultimately, having more frequent dialogue about disability accessibility in STEM courses can make a tangible difference in creating a more just and equitable learning experience for every one of our students.

Romer Prize Session (Thursday, November 3, 2022, 8:00 AM)

ORIGIN OF ENHANCED CRANIAL TACTILE SENSATION IN CROCODYLIIFORMS

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The vertebrate trigeminal nerve is the primary mediator of somatosensory information from nerve endings across the face, extending nerve branches through bony canals in the face and mandibles, terminating in sensory receptors. Reptiles have evolved several extreme forms of cranial somatosensation in which enhanced trigeminal tissues are present in species engaging in unique sensory behaviors. However, morphology varies by clade and ecology among reptiles. Few lineages have approached the extreme degree of somatosensation possessed by crocodylians, the only remaining members of a clade that underwent an ecological transition from the terrestrial to semiaquatic habitat, also evolving a specialized tactile trigeminal system. It remains to be understood how trigeminal osteological correlates inform how adaptations for enhanced cranial sensation evolved in crocodylians. Here we identify enhanced sensory abilities in Early Jurassic crocodylomorphs, preceding the transitions to a semiaquatic habitat. Through quantification of trigeminal neurovascular canal branching patterns, we find stepwise progression of neurovascular canal density, complexity, distribution, and structure from the primitive archosaurian to the derived crocodylian condition. Model-based inferences of sensory ecologies from quantified morphologies indicate a parallel increase in sensory abilities among pseudosuchians. These findings establish patterns of reptile trigeminal ecomorphology, revealing evolutionary patterns of somatosensory ecology.

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Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

A DIVERSE SHARK FAUNA FROM THE SMITHIAN-SPATHIAN INTERVAL AT ZUODENG SECTION, GUNAGXI PROVINCE, SOUTH CHINA

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With the impact of the end Permian mass extinction, the Early Triassic shark fauna is rarely discovered. Here, a diverse chondrichthyan fauna from the Smithian-Spathian interval at Zuodeng section, Guangxi Province, South China, is presented. Nine taxa are described, including three cladodont-like sharks (*Hybodus* *zuodengensis*, *Hybodus* *yohi*, and *Euselachii* gen. et sp. indet.), two hybodonts (*Omanoselache halli* and cf. *Hybodus palicalitis*), three neoselachians (*Synechodus* aff. *S. triangulus*, *Polyfacidus pandus* and *Safrodus tozeri*) and one hybodont-neoselachian shark (*Favusodus orientalis*). Apart from two endemic groups, e.g., *Hybodus zuodengensis* and *Hybodus yohi*, the rest of the tooth taxa were previously recovered from the Smithian-Spathian (Early Triassic) of Oman, Spathian-Anisian (Early-Middle Triassic) of South Japan and Ladinian-Carnian (Middle-Late Triassic) of Xingyi, Guizhou Province of South China. It not only reveals the strong paleobiogeographic affinity of shark communities between the western (Oman) and eastern (Zuodeng and Japan) Tethys during the Early Triassic, but also indicates that the Middle-Late Triassic shark faunas from Japan and Xingyi are possibly derived from the earlier shark assemblage from Zuodeng area.

Funding Sources National Natural Science Foundation of China (No. 41876124, 42172009)

Symposium: A Late Miocene Shangri-la (Wednesday, November 2, 2022, 1:45 PM)

GEOCHEMISTRY AND CLIMATE CHANGE DURING THE LATE MIOCENE AND PLIOCENE IN YUNNAN, SOUTHWESTERN CHINA

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The late Miocene through the Pliocene witnessed large-scale changes in global climate, including the continuation of the late Neogene global cooling trend that began in the middle Miocene. Yunnan Province, China, on the southeastern margin of the Tibetan Plateau, contains numerous sedimentary basins, making it an important region for research on late Cenozoic climatic change. However, most prior research on climate change in this region has relied on stratigraphic correlation, so precise chronological control has often been lacking. To further explore late Neogene climate evolution in this region, a 120 m deep borehole core was extracted ~580 m from the terminal Miocene site of Shuitangba. Paleomagnetic correlation reveals that the core sequence spans the interval from ~8.8 to ~2.6 Ma. The sediments from this core were examined for clay mineral composition and evidence of chemical weathering using three silicate chemical weathering proxies to infer broad climatic conditions. Results for this sampled interval reveal gradual cooling within generally warm and humid conditions from 8.8-6.2 Ma, followed by three more marked cooling episodes from 6.2-5.0 Ma, cool and humid conditions from 5.0-2.8 Ma, and finally, cold and humid conditions from 2.8-2.6 Ma. Variation in clay mineral assemblages and chemical weathering therefore both indicate a substantial shift in climate in the Zhaotong Basin from a warm and humid climate in the late Miocene to a cool and humid climate in the latest Miocene through the Pliocene, followed by a gradual trend towards a cold and humid climate in the very late Pliocene. The strongest cooling episode within this period is at ~6.1 Ma. Results from the period of transition between the 8.8-6.2 Ma and 6.2-5.0 Ma intervals are consistent with high-resolution palynological records of vegetational change from the Shuitangba site itself. The evidence is therefore compatible with a scenario in which terminal Miocene and later cooling episodes within a prevailing warm and humid climate, with associated changes in vegetation, likely exerted a strong influence on the composition of mammalian faunas in the region over this interval.

Funding Sources The “Strategic Priority Research Program” of the Chinese Academy of Sciences (grants: XDB26000000 and XDA13010106).

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

PERISSODACTYLS FROM THE EARLY MIOCENE OF LANZHOU BASIN, NORTHWEST CHINA

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Two different taxa of perissodactyls, *Aprotodon* (Rhinocerotidae) and *Borissiakia* (Chalicotheriidae), are reported from the early Miocene Xianshuihe Formation of the Lanzhou Basin, Northwest China (Xiejian Stage). *Aprotodon* occurs in Asia from the late Eocene to the early Miocene, and includes four species. The mandible from Lanzhou has elongated, strongly curved tusk-like incisors, a peculiar mandibular symphysis which widens sharply anteriorly, and lacks p1. Those features are different from other species (*A. smith-woodwardi*, *A. fatehjangensis*, *A. aralensis*) and support its attribution to *A. lanzhouensis*, which has also been discovered in the Erlan Basin, Nei Mongol and in the Linxia Basin, Gansu. The other mandible is most similar to the schizotheriine *Borissiakia betpakdalensis* from Kazakhstan except for a much smaller body size which is hardly explained by intraspecific variation and may represent a smaller body-sized species of *Borissiakia*. However, it also shares common features with the type specimen of *Phyllotillon huangheensis* from the same strata of the Lanzhou Basin, i.e., in the lower cheek teeth and the anterior end of the ramus which tapers more than in other taxa. Differences between both are the height of the ramus, especially the level of the symphysis, which may be explained by sexual dimorphism. Therefore, the schizotheriine mandibles from the early Miocene of the Lanzhou Basin probably represent the same taxon and both are attributed to *Borissiakia huangheensis*.

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Virtual Posters

NEW INTERPRETATIONS OF TWO LONG-FORGOTTEN FOSSIL TURTLES FROM THE PLEISTOCENE OF TAIWAN

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Misidentification of fossil materials leads to problematic interpretations. Here we reidentify the taxonomy of two long-forgotten fossil turtles from the Pleistocene of Taiwan and point to the previously hidden paleoecological implications. A fossil soft-shelled turtle was originally identified as *Trionyx liupani*, and the holotype (a well-preserved skull from the Pleistocene of Taiwan) is likely gone after our intensive search. We found the replica of *Trionyx liupani* (NTM I02038) and reexamined the skull morphology, confirming that it should belong to the genus *Rafetus* due to the posterior margin of the nasal fossa being weakly concave and much wider width of squamosals than that of jugals across the skull. Our revision of its taxonomy confirms, for the first time, the occurrence of the huge extant genus *Rafetus* in the Pleistocene of Taiwan. In addition, our estimation of its body size suggests that this individual is more than 1 m long (based on the

preserved skull width of 104 mm), indicating a profound Pleistocene faunal turnover. Similarly, the holotype of *Chinemys pani* (a complete turtle shell from the Pleistocene of Taiwan) is likely lost, and our search for the actual fossil leads us to a replica (CJSHS-911001). Our detailed morphological reexamination shows that the specimen exhibits the unique combination of extant *Mauremys reevesii*, including the presence of three longitudinal keels on the carapace, the second to sixth neural bones anteriorly short-sided, and the lack of movable plastral hinge. Further, our results confirm the original diagnostic features are polymorphic characters of *Mauremys reevesii*. This taxonomic revision resolves the debate on whether the extant *Mauremys reevesii* is a native turtle or an introduced species in Taiwan, in turn, providing a straightforward example of how fossils can be applied to conservation policies. Our new interpretations of two long-forgotten fossil turtles from the Pleistocene of Taiwan reaffirm the importance of taxonomic identification and its paleoecological implications behind. Similarly, our study reinforces the value of proper fossil curation, as vertebrate fossils have long been ignored in Taiwan, which causes the still undeveloped status of vertebrate paleontology in Taiwan.

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Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

THE BONE HISTOLOGY OF *THESCÉLOSÁURUS ASSINIBOÏENSIS* AND THE POTENTIAL UTILITY OF HISTOLOGY FOR SPECIES IDENTIFICATION

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Thescelosaurus is a genus of small basal ornithomorphs found in the Upper Cretaceous formations of North America, including the Hell Creek and Lance formations of the northern USA. A new species, *T. assiniboensis*, which is endemic to the Frenchman Formation of Saskatchewan, Canada, was recently described. *Thescelosaurus* remains an especially common in the Frenchman Formation, likely indicating their prevalence in the Late Cretaceous ecosystem. However, research on this genus has been limited due to the lack of well-preserved specimens, and many aspects of this dinosaur remain poorly understood. Here, we provide the first major histological study conducted on the genus *Thescelosaurus*, based on specimens from the Frenchman Formation. These specimens provide an ideal target to study multiple individuals of *Thescelosaurus* from a restricted geographical and stratigraphic position. In addition to the frequently sampled femora, we also sampled dorsal ribs tentatively identified as *Thescelosaurus*. It has recently been suggested that the dorsal ribs are potentially useful for histological data and our aim was to assess their proposed utility while increasing our sample size. In total, we

sampled 13 individuals represented by either femora or dorsal ribs. Our results indicate that dorsal ribs preserved growth marks better than the femora in *Thescelosaurus*. Most femora sampled here show consistent vascular organization and lack clear growth marks, however, two specimens from the sample set show distinct vascular organization and the presence of growth marks. This difference may represent distinct intraspecific differences in *Thescelosaurus* growth, or it may potentially represent interspecific differences caused by misidentified specimens. The only other small ornithopod known from the Frenchman Formation is the pachycephalosaurid, *Sphaerotholus buchholtzae*, which have postcrania that closely resemble *Thescelosaurus*. Fragmentary specimens often lack the diagnostic characteristic required to differentiate the two taxa and small ornithopod remains from Saskatchewan are usually referred to *Thescelosaurus* due to their abundance. If the structural differences observed within the histological slices represent interspecific differences, they may provide an alternate approach to differentiating between the two taxa. Additionally, the variation in the bone structure may suggest that distinct growth patterns were exhibited by the two species.

Technical Session 12: Rodents & Quaternary Mammals
(Friday, November 4, 2022, 1:45 PM)

NEW RADIOCARBON DATES ON MEGAFUNAL DUNG, INSECTS AND WOOD SHED LIGHT ON CHRONOLOGY OF NEOTROPICAL ASPHALTIC DEPOSITS

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South America experienced the most severe late-Quaternary extinctions of all continents, losing > 50 genera of large mammals, and these disappearances appear to have coincided closely with both late-Pleistocene climate fluctuations and the arrival and population growth of humans. Analyses of the extinction event on a continental scale, however, are hampered by a lack of fossil data in lowland tropical regions, where environmental and socioeconomic factors often preclude fossil preservation or recovery. Asphaltic fossil deposits (“tar pits”) are a notable exception, yielding high rates of fossil accumulation (through active entrapment), preservation (by the unique chemical properties of asphalt), and encounter (owing to their association with important extractive industries). Unfortunately, obtaining precise chronological information from these sites has so far proved largely elusive, owing to a dearth of collagen in most osteological specimens. We obtained 18 new radiocarbon dates from two neotropical asphaltic localities, Talara in northwestern Peru and Tanque Loma in southwestern Ecuador. The dates were obtained on insect and plant remains, including small, blunt-ended twigs that are inferred to represent gut contents or coprolites of giant

ground sloths (*Eremotherium laurillardii*). All dates except for one mid-Holocene stick fall within a narrow time range of between ~14,500 and 17,000 calendar years before present, indicating that both sites were preserving megafauna at the same time, and may represent much narrower periods of deposition than other well-studied asphaltic sites like Rancho La Brea (in California, USA). Notably, the new dates place these neotropical localities in a crucial interval, during the rapid deglacial warming of the Bølling-Allerød and within 500 - 1,000 years of the earliest documented human occupations in the region. This elevates the importance of these sites as potential records of end-Pleistocene ecosystem change, particularly Talara which is thought to be comparable to Rancho La Brea in taphonomy, biodiversity, and past ecosystem structure.

Virtual Posters

STABLE ISOTOPE ANALYSIS OF LATE CRETACEOUS (MAASTRICHTIAN) SHARK TEETH (*SERRATOLAMNA SERRATA*; *CARCHARIAS C.F. HOLMDELENSIS*) FROM THE WESTERN INTERIOR SEAWAY

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The Western Interior Seaway was a Late Cretaceous (100.5-66 Mya) inland sea that, at its largest, stretched north to south from the modern-day Arctic Ocean to the Gulf of Mexico. Research concerning this seaway has revealed that there was likely a significant temperature gradient present, with cooler temperate waters to the north and warmer subtropical waters to the south. I sampled fossilized teeth from two species of sharks (*Serratolamna serrata*; *Carcharias c.f. holmdelensis*) collected from an Arkansas site located in the Late Maastrichtian of the Western Interior Seaway. I used laser ablation techniques to do stable isotope analysis on 10 teeth from *S. serrata* and 8 teeth from *C. holmdelensis*. The mean $\delta^{18}\text{O}$ (VSMOW) isotopic values for *S. serrata* (22.2) and *C. holmdelensis* (22.3) indicate no significant difference in primary habitat. The mean reconstructed paleotemperature calculated from $\delta^{18}\text{O}$ data was 19.5 °C, putting this locality within the upper parameters of a warm temperate climate. The mean $\delta^{13}\text{C}$ (VPDB) isotopic values for *S. serrata* (-7.23‰) and *C. holmdelensis* (-9.58‰) indicate a difference in dietary habits or preferences. I hypothesize that these differences are attributed to significant size differences between *S. serrata* and *C. holmdelensis*. These size differences would have enabled them to fill slightly different ecological niches which would result in somewhat differing prey sources. Future research is needed to expand upon the paleoecology of Late Cretaceous sharks and the Late Maastrichtian Western Interior Seaway.

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Virtual Posters

EPIPHYSEAL HUMERAL MORPHOLOGY REVEALS FORAGING ADAPTATIONS TO CARNIVORY IN AN EXTINCT BAT

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Dietary adaptations were key factors linked to the diversification of modern bats, carnivory being one of the most striking specialisations. In bats, morphological traits often associated with adaptations to carnivory include increased body size, and cranial and dental adaptations for increased bite force and optimised shearing, respectively. However, carnivory in bats represents a gradient of specialisation, rather than discrete traits, making difficult the identification of diagnostic traits for carnivory. Postcranial adaptations that may shed light on foraging adaptations to carnivory have been comparatively less studied. The dietary ecology of most fossil bat species has been inferred from craniodental traits. Similarly, the scarcity of the bat fossil record has limited our capacity to reconstruct evolutionary trajectories of dietary specialisation. The fossil bat *Notonycteris magdalenensis* is an extinct species of the family Phyllostomidae, closely related to a group of modern carnivorous bats, including the largest bat in the Americas (*Vampyrum spectrum*). *N. magdalenensis* exhibits an ambiguous combination of traits that suggest it was both a carnivore (increased body size) and an omnivore (unspecialised dentition). Based on a 3D geometric morphometrics analysis of the distal humeral epiphysis, we compared the morphology of *N. magdalenensis* with a sample of 34 modern bat species with known foraging strategies. Principal Component Analysis revealed a differentiation of foraging guilds based on epiphyseal morphology. Trawling, terrestrial locomotors and carnivorous species occupied non-overlapping subregions of morphospace, *N. magdalenensis* clustering closest to modern carnivores. A significant effect of allometry on epiphyseal shape was found, albeit it explained less than 10% of variation, whereas statistically significant differences across foraging guilds explained 25% of shape variation. Mixture Discriminant Analysis and Canonical Variates Analysis correctly classified 100% of modern species, and inferred *N. magdalenensis* had carnivore-like foraging capabilities. We hypothesise that postcranial changes associated with foraging represent adaptations (under directional selection), whereas changes in cranial and body size represent exaptations for carnivory. Our results reveal unexplored patterns of morphological specialisation to carnivory in the humeral morphology of bats, revealing new avenues to explore the ecomorphological evolution of bats.

Technical Session 17: Fish (Saturday, November 5, 2022, 8:00 AM)

CATURID (HALECOMORPHI, AMIIFORMES) DIVERSITY IN THE LATE JURASSIC

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Caturids are among the most common predatory ray-finned fishes from the Late Jurassic. They are mainly distinguished by the presence of laterally compressed and sharply carinate acrodin tooth caps, and haemal spines transversely broadly spatulate and strongly inclined towards the notochord. Between 1833 and 1895, 36 Late Jurassic caturid species were named by different authors. Most of these taxa have been placed under synonymy or referred to other fish groups, so that the family is currently restricted to the two genera *Caturus* Agassiz and *Amblysemius* Agassiz, including four species, each with a long list of junior synonyms: *C. furcatus* Agassiz, *C. giganteus* (Wagner), *A. pachyurus* (Agassiz), and *A. bellicianus* Thiollière. Our thorough revision of the original descriptions, type material and more than 700 specimens in 61 collections worldwide, led to significant results, changing the picture of caturid diversity in the Late Jurassic. The generic name *Amblysemius* is a nomen dubium. Besides six already known cases, *Caturus velifer* Thiollière and *C. brevis* Winkler, so far under synonymy with *C. furcatus*, are referred to other taxa outside Halecomorphi. Five species names are unavailable (nomina nuda), and ten nominal species are nomina dubia due to insufficient information in the original descriptions, lack of diagnostic features in the type material or to the complete lack of type material. We confirm *C. furcatus* as the type species of the genus and remove *Strobilodus giganteus* Wagner from *Caturus* and from Caturidae. Among the remaining *Caturus* species: 1) there is a case of homonymy of a probably valid species; 2) at least *C. latus* Agassiz is a valid taxon; 3) *C. granulatus* Münster represents a new caturid genus; and 4) *C. cliffoni* Woodward is referred to *Strobilodus*. Although previously synonymized with *Caturus*, *Thlattodus suchoides* Owen and *Ditaxiodus impar* Owen are now referred to *Strobilodus*. Additionally, one new specimen represents a distinct genus, exhibiting an intermediate morphology between *Caturus* and *Strobilodus*. Our revision of the Late Jurassic caturid species led to their reclassification. We now depict two species of *Caturus*, one new caturid genus and species, while *Strobilodus* with three species is tentatively left as Amiiiformes incertae sedis. The additional new genus and species is probably closely related to Caturidae.

Funding Sources Deutsche Forschungsgemeinschaft: LO1405/6-1 (ALA).

Technical Session 12: Rodents & Quaternary Mammals
(Friday, November 4, 2022, 1:45 PM)

**VIRTUAL ENDOCAST OF THE LATE EOCENE
ANAGALE GOBIENSIS (ANAGALIDAE) OF NEI
MONGOL, CHINA: FRESH INSIGHTS ON THE BRAIN
EVOLUTION OF EUARCHONTOGLIRES**

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Anagalids are an extinct group of primitive mammals from the Asian Palaeogene thought to be possible basal members of Glires (the lineage that includes rodents and lagomorphs), although their relationships have been contested. Anagalid material is rare, with only a handful of crania known. Here we describe the first virtual endocast of an anagalid, based on the holotype of *Anagale gobiensis* (AMNH 26079; late Eocene, China), which allows for comparison with published endocasts from fossil members of modern euarchontoglian lineages (i.e. primates, rodents, lagomorphs). The endocast displays traits expected of mammals adapted to underground life, such as relatively small petrosal lobules and a low neocortical ratio, which would be consistent with previous inferences about use of subterranean food sources based on heavy dental wear. In fact, *A. gobiensis* has the lowest neocortical ratio yet recorded for a euarchontoglian. This species was olfaction-driven, based on the relatively large olfactory bulbs and laterally expansive palaeocortex. The endocast supports previous inferences that relatively large olfactory bulbs, partial midbrain exposure and low encephalization quotient are ancestral for Euarchontoglires, although the likely fossorial adaptations of *A. gobiensis* may also partly explain these traits. While *A. gobiensis* is a primitive mammal in many aspects, some of its derived endocranial traits point towards a new understanding of the diversity of trajectories of brain evolution within Euarchontoglires.

Funding Sources Kalbfleisch Postdoctoral Fellowship to SLT, Marie Skłodowska-Curie Actions: Individual Fellowship to OCB, NSERC CGS grant to MML, and NSERC Discovery Grant to MTS.

Colbert Prize Session

**ASSESSING GRADIENTS IN NORTH AMERICAN
MAMMALIAN FUNCTIONAL DIVERSITY
ASSOCIATED WITH GEOGRAPHY AND CLIMATE**

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Previous studies analyzing the diversity of North American mammalian communities have revealed the existence of taxonomic diversity gradients linked to the geography and climate of the continent. In order to gain a deeper understanding of both modern and past communities, and how the species within a certain community interact with their environment and each other, it is necessary to analyze mammalian communities' functional diversity. Our data include modern terrestrial mammal taxon lists and a suite of environmental variables representing elevation, topographic relief, temperature, and moisture availability for 1990 grid cells, each 100 km by 100 km, spanning from Canada to Panama. For each of the 749 species in the dataset, we recorded three ecological categorical variables: body size, dietary preference, and locomotor mode. Using the FD package in R, we calculated three metrics of functional diversity (functional richness, the number of functional roles present in a community; functional evenness, the regularity of how species are distributed amongst functional roles; and functional dispersion, the dissimilarity of the functional roles present in a community) across North America and compared these metrics to the geographic and climatic variables. We find that functional richness has positive correlations with species richness, elevation, and temperature; functional evenness is negatively related to species richness and has a positive correlation with latitude; and functional dispersion increases asymptotically with temperature, and is generally high in regions with high elevation, topographic relief, or species richness. Comparison of our results to null models constructed from 1000 randomly generated taxon lists for each grid cell reveal that trends in functional richness and evenness follow the patterns predicted by species randomization, however many of the observed values of functional dispersion are significantly lower than expected for a given value of species richness. These results indicate the existence of mammalian functional diversity gradients linked to the geography and climate of North America. The relationships of each metric to species richness may also have implications for understanding functional diversity of past communities, as the fossil record is incomplete due to taphonomic preservation and collection biases.

Technical Session 18: Birds (Saturday, November 5, 2022, 1:45 PM)

**USING COMPARATIVE FUNCTIONAL
MORPHOLOGY TO RECONSTRUCT LOCOMOTION
IN THE CRETACEOUS BIRD *ICHTHYORNIS*
(AVIALAE: ORNITHURAE)**

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The evolution of flight was a critical aspect to the success of modern birds (Neornithes) after the K/Pg extinction, and the avian skeleton shows unique adaptations to flight styles and other locomotory ecologies. Functional morphological traits, especially in features of the pectoral and pelvic girdles, show statistically robust associations with locomotory styles, such as soaring, burst flight, and foot-propelled diving, and these extant form-function relationships provide the opportunity to estimate locomotory modes in extinct taxa. The fossil bird *Ichthyornis* (Avialae: Ornithurae), found in Late Cretaceous shallow-water marine sediments of North America, has been hypothesized to be a volant seabird, similar to modern terns or gulls. While certain skeletal features in *Ichthyornis* have been noted to resemble diving bird adaptations, rigorous quantitative testing of locomotory hypotheses in *Ichthyornis* have yet to be performed. Here, we provide the first whole-skeleton morphometric analysis of *Ichthyornis* to test hypotheses on its locomotory ecology. We performed a 3D geometric morphometric analysis on the sternum, as well as a linear morphometric analysis of measurements across the entire skeleton of *Ichthyornis* and a broad phylogenetic scope of ecologically diverse Neornithine taxa. Locomotory variables associated with morphology were identified using a Procrustes distance-based phylogenetic generalized least squares approach, and presence of locomotory traits were estimated in *Ichthyornis* using a phylogenetic flexible discriminant analysis. We find strong support for *Ichthyornis* being both a soarer and foot-propelled underwater diver, as indicated by its sternal morphology, which is similar to the extant darter (*Anhinga anhinga*: Suliformes). We also find that the sternum alone provides much greater predictive power for locomotory mode than overall skeletal proportions. Our study is the first detailed statistical analysis of *Ichthyornis*' locomotory ecology, and suggests an earlier origin of foot-propelled diving in birds than previously estimated. Further, these results underscore the importance of sternal morphology in the origin and evolution of flight across the dinosaur-bird transition, and suggest that functional ecological traits may require more complex characterization than discrete categories have allowed.

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Education & Outreach Poster Session

FOSSILS AND FIFTH GRADE: PROFESSIONAL DEVELOPMENT TO IMPROVE TEACHING AND LEARNING

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Teacher professional learning experiences are an effective way to increase teacher knowledge and ultimately student outcomes. However, access to quality programs is not universal, with rural communities often lacking in resources. In this project, the Center for STEM Education at Georgia Southern University and the Georgia Southern Museum partnered to provide hands-on learning experiences, externships, and pedagogical support for fifth-grade teachers in rural Evans County, Georgia. Training was centered around the state academic standard that focuses on sorting and classifying animals and plants. Prior to training, teachers answered a questionnaire aimed at determining gaps in understanding. The initial training was held on-site at the elementary school. The Georgia Southern Museum conducted a hands-on teaching session centered around vertebrate and invertebrate fossils aimed at clearing misconceptions and providing teachers with examples of hands-on and virtual activities that could be used in the classroom. In the summer, teachers experienced individual externships in the museum, working with collections and the public in order to develop a place-based understanding of fossil taxa found in the coastal plain of Georgia. Teachers were challenged with creating a curriculum plan to include an interdisciplinary, hands-on, and place-based focus, incorporating lessons learned from their experience with the Georgia Southern Museum. The Center for STEM Education provided support for teachers as they developed and implemented their lesson plans. Through sustained interaction between the fifth-grade teachers, the museum, and the university, teachers not only developed a creative and accessible curriculum for their students, but they also provided students with a better understanding of paleontological research in museums and universities. In addition, this partnership also encouraged extended learning opportunities in the form of school field trips and individual visits to the museum.

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

ANATOMICAL VARIATION IN RESPIRATORY AND OLFACTORY TURBINATES IN EXTANT AND FOSSIL SCIUROID RODENTS

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Modern sciuroid rodents are characterized by an incredible ecological diversity combined with a substantial fossil record, allowing us to explore the emergence of this diversity and reconstruct ancestral states of morphological characters. Here

we focus on turbinates which are scrolls of bone in the nasal cavity covered to varying degrees in either respiratory or olfactory epithelium. These turbinates are then often used as proxies for the relative importance of either function. Unfortunately, turbinates are rarely preserved and have never been described in detail for a fossil sciuroid, limiting the degree to which we understand nasal anatomy evolution within this diverse group. Here, we present both modern sciuroid turbinate anatomy as well as the first description of well-preserved turbinates in a fossil representative. We used micro-CT scan data to digitally extract and compare extant sciuroids ($n = 22$) and reconstructed ancestral turbinate number and relative size at each major internal node. We describe the anatomy of the Orellan aplodontiid rodent, *Prosciurus relictus* (USNM PAL 437793) from the Oligocene White River Formation. We found that this taxon preserves two frontoturbinates, four ethmoturbinates, one interturbinate and a branching maxilloturbinate. This turbinate count is consistent with our ancestral state predicted by our modern sample of sciuroids. However, *Prosciurus* differs from its closest extant relative, the aplodontiid *Aplodontia*, in lacking the highly arborized respiratory turbinates that characterize this taxon. *Prosciurus* further differs from *Aplodontia* in lacking the dorsoventrally compressed olfactory turbinates observed in the modern taxon. We also find that while there is considerable variation in turbinate morphology and size, this clade is remarkably consistent in turbinate number, which differs from other well described groups that share similarly varied ecological strategies (e.g. strepsirrhine primates). When testing for disparity in relative olfactory or respiratory turbinate surface areas along ecological variables, there were no significant differences among extant sciuroids when grouped by either locomotor mode or activity pattern. Those results demonstrate that turbinate numbers within sciuroids are relatively constant while morphology and relative size vary. Even though the ecological pressures driving this increase in size remain unclear, future work will investigate the impact of other factors such as diet.

Funding Sources School of Graduate Studies Travel Grant and Research Expenses Grant from the University of Toronto, Canada

Technical Session 11: Synapsida (Friday, November 4, 2022, 8:00 AM)

INCONGRUENCE OF MORPHOLOGICAL DISPARITY AND EVOLUTIONARY RATE IN THE FORELIMBS OF PALEOZOIC SYNAPSIDS

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Previous work has shown increased morphological variance within the forelimbs of the Permian synapsid group known as

Therapsida over that of their Carboniferous and early Permian forerunners (“pelycosaurs”). Considering that disparity trends have been known to point to underlying macroevolutionary transitions, here we analyzed morphological variance alongside several additional macroevolutionary metrics to better isolate possible evolutionary mechanisms. Shape data was collected on a sample of 119 humeri and 99 ulnae comprising three major synapsid radiations with a temporal range from the Carboniferous into the Triassic. Taxonomic sample included all major groups of pelycosaur-grade synapsids, all five recognized non-cynodontian therapsid clades, and a sample of pre-prozostrodonian cynodonts. Procrustes variance - a multivariate quantification of morphospace occupation - was the chosen disparity metric for the study. Rate of phenotypic change, which considers the amount of shape change that would be necessary to achieve observed morphologies given the shape of the closely related taxa, was analyzed as the metric for evolutionary rate. Both metrics were considered through-time upon genera present in sequential 5 million year time bins.

Our results expand upon previous findings that disparity increases throughout the earliest stages of the Permian, coincident with the diversification of pelycosaurs and the emergence of Therapsida. This expanded dataset further shows that disparity approaches an asymptote around 270 million years ago and only increases marginally through the late Permian, remaining between 0.018–0.021 from 275–245 mya. In contrast, evolutionary rate does not appear to asymptote during this same interval, starting at a low of $6.17e-6$ (300 mya) and increasing to a peak of $1.78e-5$ right before the End Permian Mass Extinction Event (252 mya). The continuing increase of evolutionary rate shows that morphological change continues across taxa, but the plateauing of morphological disparity suggests that morphospace is not expanding concurrent with this. The incongruence between these two metrics suggests a critical change in evolutionary mode, wherein morphological change continues rapidly but does not result in the evolution of novel morphologies. These results provide some of the strongest quantitative data yet of an evolutionary constraint acting upon the morphology of the synapsid forelimb through deep time.

Funding Sources NSF grant DEB-1754502

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

POPULATION VARIATION AND BIOGEOGRAPHY OF EXTINCT SPECIES OF RODENTS FROM THE ISLAND OF HISPANIOLA

Luthra, Alisa, Vinola, Lazaro W.

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The island of Hispaniola is the center of the speciation of rodents within the Caribbean; however, most species have

become extinct within the last two thousand years, due to both human and natural impacts. Studies on extant species of rodents from Hispaniola have shown the existence of morphometric and body mass differences from distinct biogeographical regions within the island. However, it remains unknown if extinct species follow a similar pattern. As a part of the 2021 iDigBio-Summer Internship Program, graduate and undergraduate researchers used morphometric data of five extinct Hispaniola rodent species to test whether ancient populations demonstrated differences in morphometrics and body mass in correlation to the biogeographical regions of Hispaniola. Specimens were sourced from the vertebrate paleontological collections of the Florida Museum of Natural History. Measurements were taken of cranial and mandibular elements of the caviomorph hutia species *Plagiodontia ipnaeum*, *P. araeum*, *Hexolobodon phenax*, *Isolobodon montanus*, and *I. portoricensis*. Statistical analysis revealed that there are significant differences in the morphometrics and body mass of populations of the five species sampled, and these differences correlate to the unique biogeographical regions of Hispaniola. Knowing that extant biogeographical trends extend into the paleontological record provides us with a baseline for future comparative studies.

Funding Sources Funding for the 2021 iDigBio-Summer Internship Program, including conference attendance, is provided by the National Science Foundation under Grant Number DBI-1547229.

Technical Session 10: Soft Tissues & Taphonomy (Friday, November 4, 2022, 8:00 AM)

TAPHONOMY OF MARINE REPTILES AND DINOSAURS OF THE UPPER CRETACEOUS MORENO FORMATION, CALIFORNIA

Lyman, Theophan

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The Moreno Formation in California provides well-preserved fossils of marine reptiles and dinosaurs. This study examines the preservation quality of 97 mosasaurs, plesiosaurs, and hadrosaurs of the Upper Cretaceous portion of the Moreno Formation. Seventy-seven mosasaur, 15 plesiosaur, and 5 hadrosaur specimens are analyzed at the University of California Museum of Paleontology in Berkeley and the Natural History Museum of Los Angeles County. The specimens' average skeletal completeness, skeletal abrasion, weathering, fragmentation, compression, and bone damage marks are researched between three vertebrate groups and three sedimentary members. The obtained results show that (1) the average skeletal completeness of mosasaur, plesiosaur, and hadrosaur specimens of the Moreno Formation is higher than that of these taxa in other fossil sites in North America and abroad, (2) the preservation of the plesiosaurs is the most remarkable, followed by that of the mosasaurs and hadrosaurs,

and (3) fossil preservation is varied among different sedimentary members of the Moreno Formation. The exceptional preservation of the Moreno Formation specimens has important implications for the study of the functional morphology, systematics, phylogenetic reconstruction, paleogeography, and regional stratigraphy of mosasaurs, plesiosaurs, and hadrosaurs in the Upper Cretaceous Pacific Coast of North America.

Technical Session 2: Paleoecology (Wednesday, November 2, 2022, 8:00 AM)

NEW INSIGHTS INTO THE PALEOECOLOGY OF THE EARLY PERMIAN BROMACKER LOCALITY, THURINGIA, GERMANY, BASED ON ANALYSES OF RELATIVE ABUNDANCE

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Over the last several decades the Bromacker quarry located in the Tambach Basin of central Germany has produced a large and distinctive early Permian fauna, represented by well-preserved tetrapod skeletons and trackways. To better understand the paleoecology and faunal composition of the Bromacker locality we used all currently known skeletal remains and numerous trackways to analyze the relative abundances of Bromacker tetrapods using several metrics. The results of these analyses reveal important details regarding the Bromacker tetrapod fauna. The most immediately obvious is that diadectids are very clearly the most abundant group present at Bromacker, both when using skeletal remains and trackways. Reptile abundance is also quite high at the locality, in particular the relative abundance of captorhinids (*Thuringothyris*) is only surpassed by that of the extremely abundant diadectids. In contrast, the skeletal remains of bolosaurid reptiles (*Eudibamus*) are very rare, but trackways attributed to the group are substantially more abundant. Synapsid taxa are found to be uncommon in comparison to the reptiles from the locality, with all known synapsids having very low relative abundances, though synapsid ichnotaxa are more abundant. Overall, it is quite apparent from these analyses that the Bromacker fossil assemblage is dominated by herbivorous diadectids, with carnivorous taxa being less common. This suggests a herbivore dominated trophic structure reminiscent of what is observed in modern terrestrial ecosystems, where herbivorous tetrapods are more abundant than predators. This is a type of ecosystem that was not prevalent during the early Permian, making Bromacker the earliest example of a terrestrial ecosystem dominated by herbivorous tetrapods.

REVIEWING THE KNOWLEDGE OF NORTH AND CENTRAL AMERICAN *EQUUS*

Machado, Helena¹, Barrón-Ortiz, Christina Isabelle², Arroyo-Cabrales, Joaquín³, Landry, Zoe⁴, Marín-Leyva, Alejandro⁵, Scott, Eric⁶, Cirilli, Omar⁷, Davis, Edward B.¹, Bernor, Raymond⁷

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North and Central American horses have been commonly found in numerous terrestrial vertebrate faunas since the 18th century. The first several *Equus* species were discovered and described while the International Code of Zoological Nomenclature was still in development which, combined with the lack of morphological variation analysis, led to an overgrowing and split taxonomy. Several names faded into oblivion, but some have continued to be used regardless of inadequate type materials. Despite the review work that has been done in the past decades, there is still no consensus on North and Central American *Equus*. In this work, we reviewed and summarized the taxonomic conclusions of sixty-seven studies published between 1901 to 2021. Based upon this summary, taxa-concept-maps were created to visualize the taxonomic conclusions of the surveyed literature and to identify potentially valid species. The taxa-concept-maps revealed three distinct clusters of names: one of mostly Blancan species, a Irvingtonian-Rancholabrean stilt-legged species, and a Irvingtonian-Rancholabrean stout-legged species. The identification of potentially valid species was based upon the evaluation of type and referred specimens and on how many studies considered a species valid, a *nomen dubium/nomen nudum*, or synonymized/reidentified with another species. We identify sixteen potentially valid species for the Pleistocene of North and Central American *Equus*: *E. calobatus*, *E. cedralensis*, *E. conversidens*, *E. cumminsii*, *E. enormis*, *E. francisci*, *E. fraternus*, *E. idahoensis*, *E. lambei*, *E. mexicanus*, *E. occidentalis*, *E. pseudoaltidens*, *E. scotti*, *E. simplicidens*, *E. stenosis anguinus*, and *E. verae*. This contribution aims to provide a useful foundation for future studies on the evolution and taxonomy of *Equus sensu lato*, as the potentially valid species can be recognized as taxonomic hypotheses to be tested with further morphological and molecular studies.

Funding Sources FuTRES (Functional Trait Resource for Environmental Studies)

A JACAREAN CAIMANINE SKELETON FROM THE MIDDLE MIOCENE OF COLOMBIA AND THE ORIGINS OF LIVING SPECTACLED CAIMANS

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Living caimanines include both species of smooth fronted caimans (*Paleosuchus*) and at least four species of spectacled caimans (*Caiman* spp. and *Melanosuchus niger*), included in the clade Jacarea. The earliest known caimanines occur in the latest Cretaceous of North America, dispersing into South America during the early Paleogene, with several dispersal events between both continents through the Cenozoic. Several caimanine fossils are known from the middle to late Miocene of equatorial South America. Most of these occurrences represent extremely specialized forms, whereas early representatives of modern lineages are in most cases represented by fragmentary specimens. Therefore, the origin of living caimanine clades is not well represented in the fossil record. In 2019, an articulated, well preserved caimanine skeleton was collected in the La Victoria Formation of the Honda Group in the La Venta area (middle Miocene). Preparation of the preserved skull reveals a partial cranium and articulated mandible, together with portions of the hyoids and several elements of the atlas-axis complex. The cranium exhibits several characters consistent with caimanines, such as a dorsally shifted *foramen aerum*, dermal bones of the skull overhanging rim of the supratemporal fenestra, ectopterygoid-ptyergoid flexure, and flared dorsal end of hyoid cornua. The incisive foramen projecting between the first premaxillary alveoli, and medially bowed lateral margin of the suborbital fenestra are consistent with jacareans. The lack of a vomer exposure between the premaxillae and maxillae indicates that the specimen cannot be referred to *Melanosuchus*, and suggests affinities with living and extinct *Caiman*. The preserved margin of the naris indicates that this opening was large and wide, suggesting affinities with *Caiman* cf. *lutescens* from younger sediments in the La Venta Area. However, it is not possible to discern if the lacrimal and nasal were separated by the prefrontal, as in this taxon, or were in contact as in other jacareans. This new specimen will help to increase our knowledge on the origin of spectacled caimans, a potential that will be unveiled by further preparation of the cranium and postcranium. The specimen studies in this work was collected in a joint effort by the Fundación Vigías del Patrimonio Paleontológico La Tatacoa, the Smithsonian Tropical Research Institute, the University of Zurich, Universidad del Norte, Universidad del Rosario, and University EAFIT.

Funding Sources Colombian Ministry of Science, Technology and Innovation, National Doctoral Scholarship 757

Technical Session 12: Rodents & Quaternary Mammals
(Friday, November 4, 2022, 1:45 PM)

A NICE DATE AT THE BEACH: RADIOCARBON ANALYSIS OF A RANCHOLABREAN MARINE TERRACE LOCALITY AT VANDENBERG AIR FORCE BASE, SANTA BARBARA COUNTY, CALIFORNIA

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Since its' discovery in 2012, the Eiko's Elephant Graveyard (EEG) locality at Vandenberg Space (Air) Force Base (VAFB) has become one of the largest and most diverse Rancholabrean fossil localities on the central coast of California. Among the fauna present at EEG are two giant ground sloth taxa (*Paramylodon harlani* and *Megalonyx jeffersonii*), mastodon (*Mammuthus pacificus*), camel (*Camelops hesternus*), Smilodon (*Smilodon fatalis*), horse (*Equus* sp.), bison (*Bison* sp.), pond turtle (Emydidae indet.), and small birds. Analysis of the depositional environment indicates that the area was likely a small watering hole in a coastal alluvial floodplain.

Recent excavations have focused on a slope directly north of the main quarry, where a complete *Megalonyx jeffersonii* skull and multiple *Mammuthus pacificus* and *Paramylodon harlani* elements have been recovered. These new finds on the northern slope appear to be stratigraphically higher than the main quarry and were assumed to be slightly younger. An erosional drainage separates the northern slope from the main quarry.

Recent, detailed geologic mapping of the marine terraces at VAFB throws doubt on the age of the terrace of the EEG quarry. Previous research placed the wave-cut platform at the base of the terrace as oxygen isotope stage 5a (80ka), although isolated remnants of a lower, younger terrace are present immediately adjacent to the EEG quarry. In an attempt to enhance the stratigraphic interpretations, we collected carbon-rich sediment and carbonized plant material samples from the recently excavated *Megalonyx* and *Mammuthus* specimens from the northern slope and multiple horizons of the main quarry for radiocarbon dating of the depositional environment. The samples from the main quarry (horizons 1 and 3) date to 16.9-16.2ka (cal BP), whereas the date for the northern expansion overlaps slightly and may even be significantly older than the main quarry (17.8-16.7ka [cal BP]).

Field crews are currently using photogrammetry, LiDAR, and sub-centimeter stratigraphic analysis to determine whether faulting has occurred, resulting in the stratigraphic offset between the two areas. In addition, excavations in both the northern expansion and main quarry, and a combined archaeological and paleontological study of the overlying

sediments, are ongoing. The discoveries at the EEG quarry continue to provide valuable insight into the late Pleistocene fauna and paleoenvironments of the central coast.

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

REVISED OSTEOLOGY AND PHYLOGENETIC AFFINITIES OF *AJKACERATOPS KOZMAI* FROM THE SANTONIAN (UPPER CRETACEOUS) OF HUNGARY

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Ceratopsian dinosaurs represented dominant faunal components of North American and Asian Late Cretaceous terrestrial ecosystems. Discoveries from other continents have been extraordinarily rare and their ceratopsian affinities have been often questioned. Arguably the most significant and best preserved material, originating outside the North American and Asian deposits, and assigned to Ceratopsia, has been unearthed from the Santonian (Upper Cretaceous) of Ithakút, western Hungary, and introduced as a *Bagaceratops*-like taxon named *Ajkaceratops kozmai*. The taxon was established upon a partial cranial material and was interpreted to preserve the rostral bone. Among ornithischians, this element is unique to Ceratopsia and present in all its members. However, the morphology of the proposed rostral of *A. kozmai* differs substantially from that of ceratopsians. It is subcircular in cross-section, lacking the sharp lateral edges, and its ornamentation consist of pits rather than longitudinal grooves. Additionally, its complete fusion with the premaxillary, assumed for *Ajkaceratops*, is highly uncommon for the clade members, being developed only in some ontogenetically old specimens of the latest-diverging ceratopsids. The nature of the horizontally-oriented premaxillo-maxillary fenestration, with nasals excluded from its dorsal border, is also unlike the condition observed in Neoceratopsia. The interpretation of the presence or absence of the rostral bone strongly affects the phylogenetic placement of *A. kozmai*. While it cannot be ruled out at present that *A. kozmai* represents an unusual ceratopsian dinosaur with peculiar character distribution, its affinities to Asian protoceratopsids are doubtful. The precise position of *Ajkaceratops* among ornithischians needs to be treated as unsettled and subject for further investigation.

Funding Sources This project is supported by National Science Centre, Poland, grant no. 2020/37/B/NZ8/01321.

Technical Session 7: Paleogene Mammals & Primates & Carnivora (Thursday, November 3, 2022, 1:45 PM)

A NEW DRYOLESTOID SPECIMEN FROM THE LATE JURASSIC PROVIDES NEW INSIGHTS ON THE

SIGNIFICANCE OF TOOTH ROOT STRUCTURE THROUGHOUT MAMMAL HISTORY

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Dryolestidan mammals are diverse with a wide distribution in the Jurassic and Cretaceous on the Laurasian continents, plus Africa. They are diagnosed by derived dental characters, including high molar counts (up to nine lower molars), zalambdodont-like upper molars, and lower molars with a single cusp on the talonid “heel.” Some dryolestidans also exhibit a derived morphology of lower molar roots: the mesial root is larger and more expanded mesiodistally than the simple and smaller distal root. Here we report on a new dryolestid specimen (KUVF 134101) from the Late Jurassic Morrison Formation in Wyoming, USA that we tentatively refer to *Laolestes eminens*. CT visualization of this new specimen revealed new patterns of variation in the molar roots. From p4 to m6, the mesial root for each tooth is greater than the distal root in diameter and length. In m2-m6, the mesial root is kidney-shaped in cross-section with a concave internal face; it envelops the distal root. In lateral view, the tooth roots in the mandible also change their angle consistently from being posteriorly directed in the p3-p4, to nearly vertical in m1-m4, and anteriorly oriented in m5-m6.

These new observations in KUVF 134101 prompted us to employ a morphometric approach to examine tooth roots in modern and fossil mammals, and to explore their functional significance across evolutionary timescales. To date, the evolution and functional morphology of molar crowns have been examined extensively for early mammals, including dryolestids. Key innovations like the precise occlusion of upper and lower molars, and the evolution of tribosphenic molars are two examples of how changes in dental and jaw morphology can increase biomechanical efficiency in mastication and facilitate more versatile feeding adaptations. However, few studies have focused on the evolution of the tooth roots or have investigated the functional relationship between the tooth crowns, roots, and jaws. We made measurements of the tooth roots associated with biomechanical function in modern didelphids. Our pilot results recovered consistent gradients in shape and orientation of the tooth roots from the anterior to posterior end of the mandible in modern didelphids. These patterns have functional implications and can be compared to those found in dryolestidans. Therefore, variance in tooth roots across evolutionary timescales can be useful for testing hypotheses of functional evolution of roots in early mammals.

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

EXCEPTIONALLY HIGH RATES OF TOOTH DEVELOPMENT AND REPLACEMENT IN EARLY PERMIAN HYPERCARNIVORE REVEAL HIDDEN DENTAL COMPLEXITY AMONG EARLY AMNIOTES

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The oldest known complex terrestrial vertebrate community evolved in the Permo-Carboniferous and was dominated by reptilian and synapsid amniotes. Notable among them were the first gracile hypercarnivorous varanopids, a successful clade of amniotes with wide geographic and temporal distributions throughout Pangea that also showed evidence of parental care. Little is known about their dentition and feeding behaviour, but the unprecedented number of specimens of the varanopid *Mesenosaurus* from cave deposits in Oklahoma, USA, has allowed us to show that it exhibited exceptionally rapid rates of tooth development and greatly reduced tooth longevity relative to other terrestrial amniotes. *Mesenosaurus* is also characterized by the presence of serrations along its cutting edges, a condition only seen among the extant terrestrial vertebrate, the Komodo dragon (*Varanus komodoensis*), indicating that they shared similar defleshing feeding behaviours. Interestingly, our study shows that the coeval large apex predator *Dimetrodon* greatly increased its overall dental longevity by increasing tooth thickness and massiveness, while herbivores greatly reduced tooth replacement rates and significantly increased dental longevity for dealing with cellulose-rich plants. Insectivorous and omnivorous amniotes maintained more modest replacement rates and dental longevity, likely representing the primitive condition. The distinct patterns of dental development and replacement among these early terrestrial amniotes reveal a hidden aspect of dental complexity in the emerging diverse terrestrial amniote community, very soon after their first appearance in the fossil record.

Funding Sources Natural Sciences and Engineering Research Council of Canada (NSERC) - Canada Graduate Scholarships – Master’s (CGS M)

Technical Session 1: Dinosaurs (Wednesday, November 2, 2022, 8:00 AM)

NEW ORNITHISCHIAN DINOSAURS FROM THE WEALDEN SUPERGROUP OF SOUTHERN ENGLAND

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The Wealden Supergroup of southern England was deposited by rivers and on tidally-influenced, broad, flat flood plains during the Lower Cretaceous. Historically important because the earliest dinosaur fossils recognised as such were found in its rocks, the Wealden Supergroup is thought to have been deposited immediately after the purported end-Jurassic extinction, at a time globally poorly-sampled for dinosaurs. The dinosaurs of the Wealden therefore offer us the opportunity to investigate faunal recovery in the aftermath of this apparent extinction event. We examined historical material of iguanodontians and ankylosaurs in museum collections, as well as newly collected specimens. Using an autapomorphy-driven approach, we reappraised iguanodontian material from the Hastings Beds Group of Sussex and found that at least two distinct taxa can be recognised based on features of the dorsal vertebrae, in material previously referred to *Hypselospinus*, and we also recognise the validity of the dubious taxon *Sellacoxa*. Our reappraisal of the holotype material of *Mantellisaurus* from the Wessex Formation of the Isle of Wight has identified autapomorphies of the skull and forelimb, allowing comparison with numerous other historically and newly collected specimens. This enabled recognition of *Brighstoneus simmondsi*, which possessed a *bullana nasalis*, and two additional taxa characterised by autapomorphies of the skull, dorsal and caudal vertebrae. A new ankylosaur from the Wessex Formation differs from *Polacanthus* by features of the cervical and dorsal vertebrae and the ilia, and is phylogenetically distant from the latter. The Wessex Formation spans a time period of between about 4 and 15 million years, so it is unsurprising that the diversity of dinosaurs within it is higher than previously thought. The diversity of ankylosaurs and iguanodontians in the Wealden Supergroup is significantly higher than in the roughly contemporaneous Cedar Mountain Formation of the western USA based on current evidence.

Funding Sources JAB is funded by the Leverhulme Trust

Virtual Posters

THE NORTHERNMOST CENOZOIC ATLANTIC COASTAL PLAIN OCCURRENCE AND FIRST REPORT OF THE WHALE SHARK, *RHINCODON TYPUS* SMITH, 1829 FROM MONMOUTH COUNTY, NEW JERSEY, USA

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The whale shark, *Rhincodon typus* Smith, 1829, is reported for the first time from a fossil tooth recovered from a lag deposit at the contact between the Squankum Member of the Shark River Formation and the Asbury Park Member of the Kirkwood Formation (middle Eocene-early Miocene) in Farmingdale, Monmouth County, New Jersey. This tooth

represents the northernmost occurrence of this species from the middle Cenozoic of the Atlantic Coastal Plain, and was associated with a diverse assemblage of chondrichthyans, including megatoothed sharks, and osteichthyans. Although the Farmingdale assemblage consists primarily of nearshore species, the infrequent occurrence of pelagic and deep-water taxa including the whale shark, *R. typus*, suggests a nutrient-rich environment existed in this region of the New Jersey outer coastal plain during the middle Cenozoic. The occurrence of a fossil *R. typus* tooth in the Farmingdale chondrichthyan assemblage approximately 12 km from the nearest modern shoreline also represents an excellent proxy and predictor of future sea-level change and habitat shifts in a rapidly warming modern world.

Technical Session 15: Theropods (Saturday, November 5, 2022, 8:00 AM)

A NEW CARCHARODONTOSAURID FROM THE NEUQUÉN GROUP, PATAGONIA, ARGENTINA, WITH A NEAR COMPLETE SKULL AND FORELIMBS INFORMS EVOLUTIONARY TRENDS IN THEROPOD ARM REDUCTION

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The Carcharodontosauridae were dominant dinosaurian predators that inhabited most continents during the Early to early Late Cretaceous, reaching sizes rivaling those of later living tyrannosaurids during the Aptian–Turonian. Despite a number of important discoveries over the last three decades, critical aspects of their anatomy, especially with regard to their skulls, forelimbs, and feet, remain poorly known. A new carcharodontosaurid, *Meraxes gigas*, based on a specimen recovered from the Upper Cretaceous Huincul Formation (Cenomanian–Turonian) of northern Patagonia, Argentina, includes the most complete cranial, pelvic, and appendicular remains for late-diverging members of

Carcharodontosauridae. Phylogenetic analysis places *Meraxes* among derived Carcharodontosauridae, in a clade with other massive South American species that we name Carcharodontosaurinae. *Meraxes* is diagnosed by the unique pattern of rugosities on its facial bones, co-ossified sacral neural spines forming an inverted yoke-like profile, and unique pneumatization of the proximal caudal neural arches and postzygapophyses. It represents the fourth carcharodontosaurine to be named from early Late Cretaceous strata of Patagonia and provides further evidence that carcharodontosaurids reached peak diversity shortly before their extinction. These penecontemporaneous taxa differ in pelvic anatomy and in aspects of their facial ornamentation, which may have been linked to a social signaling role. *Meraxes* preserves nearly complete forelimbs which provide evidence for a statistically significant degree of convergence in forelimb reduction between carcharodontosaurines, tyrannosaurids, and abelisaurids. Similar allometric trends in these three lineages coupled with a hypothesized lower bound on forelimb reduction around a ratio of 0.4 forelimb/femur length, combined to produce the familiar short-armed bauplan of large bodied, megapredatory theropods with large skulls. We tested the correlation between skull size and relative forelimb length using multiple regression analyses while controlling for phylogeny. These analyses indicate that as skull size increases, the correlation between femur length and arm length decreases. This result supports the hypothesis that forelimb reduction is likely not the result of adaptation for a particular function, nor a direct consequence of body size increase, but rather that it tracks some other trait, which for large predatory species is skull size.

Funding Sources National Geographic Society, Villa El Chocón, Fundación “Félix de Azara”, and Field Museum supported fieldwork. CONICET funds JC, SA, PG, & FG ; US NSF funds PJM, NDS.

Technical Session 15: Theropods (Saturday, November 5, 2022, 8:00 AM)

HOW BIG COULD *T. REX* GET? A CASE STUDY FOR THE ESTIMATION OF MAXIMUM BODY SIZE IN EXTINCT ANIMALS

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Most extinct vertebrate species are represented by very few specimens representing a tiny fraction of the total population across the history of the lineage. Arguments about which of a handful of incomplete specimens might be the largest pale against what would have been the largest ever individuals of a species. To illustrate the point, we modelled a population of the giant theropod *Tyrannosaurus rex*, accounting for somatic growth rate, age distribution, variation in asymptotic body size, and fossil sampling bias. For a total population of 140

million *T. rex* (the minimum total population size recently estimated for the species), we estimate a maximum-sized individual of ~13,000 kg, almost 50% more massive than the currently largest known *T. rex* individual. For a total population of 2.5 billion individuals, we would expect the largest ever individual to have been considerably larger still (~15,000 kg). We estimate that ~500 specimens would be needed to recover an animal that weighed 10,000 kg, and at current sampling rates this will take over a century. Arguments over ‘which was the largest theropod’ (or similar) are effectively redundant when a handful of specimens are unlikely to represent the uppermost percentiles of body size for the species, let alone the largest individual that ever existed. The implications of giant size on the ecology and behaviour of fossil animals are probably more fruitful lines of study.

Funding Sources Research funding provided by the Canadian Museum of Nature.

Romer Prize Session (Thursday, November 3, 2022, 8:00 AM)

JOINT SURFACE INTERACTIONS DISTINGUISH DINOSAURIAN LOCOMOTOR POSES

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Paleobiological estimates of joint mobility play a critical role in reconstructing the locomotion of extinct animals. Although recent studies have increased the rigor of such estimates, they continue to be hindered by a lack of explicit and transferable criteria for evaluating whether joints are “properly articulated” or not. Here I argue that paleontologists have a centuries-old intuition for what an articulated joint should look like – it simply needs to be formalized. Towards this end, I propose a novel, automated analysis that measures the three-dimensional interactions between bony articular surfaces to generate a reproducible distribution of articulation scores across joint pose space. This approach relies on data from bones alone – with no information or assumptions about the size, shape, or material properties of other articular tissues such as cartilage, ligaments, menisci, or bursae – meaning it has the potential to be applied to the fossil remains of extinct taxa. I first analyzed the articulation of the ankle, tarsometatarsophalangeal, and pedal interphalangeal joints of the extant Helmeted Guineafowl (*Numida meleagris*) and emu (*Dromaius novaehollandiae*). Comparing these results with experimentally derived locomotor kinematics revealed that articulation analyses can not only rein in estimates of joint mobility – but can even distinguish the specific subset of joint poses used in terrestrial locomotion from among hundreds of millions of potential configurations. Building from these ground-truthed findings, I then conducted articulation analyses for the metatarsophalangeal and interphalangeal joints of three extinct theropod dinosaurs. Assuming that similar principles govern the development of articular surface geometry across theropods, my results suggest that during terrestrial locomotion, non-avian dinosaurs used a fundamentally

different coordination among their pedal joints than ground-dwelling birds. This information can be applied directly to future locomotor reconstructions of dinosaurs, and the methodological framework described here can be expanded to additional taxa and joints to investigate the evolution of locomotion throughout the vertebrate tree.

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Technical Session 11: Synapsida (Friday, November 4, 2022, 8:00 AM)

UPPER CARBONIFEROUS “PELYCOSAURS” OF LINTON, OHIO, REVISITED, AND NEW INSIGHTS INTO THE EARLY EVOLUTION OF HERBIVORY IN SYNAPSIDS

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The early record of Carboniferous pelycosaurian-grade synapsids is rare. The classic locality of Linton, Ohio (Moscovian, Upper Carboniferous), has yielded only a handful of synapsid specimens, most of which have been referred to *Archaeothyris*, an inadequately known genus based upon coeval material from Nova Scotia. A recently prepared Linton specimen that includes cheek and mandibular elements represents a relatively large ophiacodontid indistinguishable from specimens from Garnett, Kansas, that were provisionally referred to *Clepsydrops*. Whereas the Ohio and Kansas specimens clearly do not pertain to *Archaeothyris*, the status of the fragmentary *Clepsydrops* type material, known from the Danville Bonebed of Illinois, is uncertain.

Two other Linton specimens rendered in high resolution X ray tomography establish a new genus of edaphosaurid and, thus, the earliest record of the clade. Despite having a longer *Ianthasaurus*-like skull, phylogenetic analysis recovers the new taxon as more derived than its Carboniferous relative *Ianthasaurus* and in a polytomy with *Glaucosaurus*, *Gordodon*, and *Edaphosaurus*. The unique presence of large, bulbous, and single-cusped teeth distinguishes the new taxon from all other known species of Edaphosauridae. This dental structure suggests some form of durophagous omnivory or low-fiber herbivory. The durophagous tooth structure found in the new taxon is congruent with new dental data on the dietary habits of pantylid “microsaurs” and recumbirostrans of the

same age. Together, these data suggest some form of durophagy or low-fiber herbivory was widespread during the Moscovian.

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

EXCEPTIONALLY PRESERVED MICRORAPTORINE FROM THE EARLY CRETACEOUS OF CHINA PROVIDES NEW DATA ON MORPHOLOGICAL VARIATION THROUGHOUT THE COMPLETE TOOTH ROW IN MICRORAPTORINAE

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Microraptorinae is a clade of small-bodied dromaeosaurs known from the Cretaceous of Asia and North America which possess a mosaic of both avian and non-avian dinosaurian traits, making them one of the most important groups in understanding the dinosaur-bird transition. Although several microraptorine species have since been named and described and their skeletal anatomy is becoming increasingly well known, a detailed understanding of the morphology and variation in their teeth is poorly documented, primarily due to poor preservation of craniodental material. A new microraptorine specimen from the Early Cretaceous Jiufotang Formation of China has a near-complete suite of exceptionally well-preserved teeth in both upper and lower jaws. The fine preservation allows quantification and analysis of the morphological variation within the tooth rows of a single individual. Here we describe the dentition of this specimen in detail, providing novel data on a complete tooth series of a microraptorine dinosaur. A computed tomography (CT) scan was performed to better visualize and measure each individual tooth present. There are 4 tooth positions in the premaxilla, at least 9 in the maxilla, and an estimated 15 in the dentary. The premaxilla bears three laterally compressed and unserrated teeth. The six erupted teeth in the left maxilla are posteriorly recurved; from the fourth tooth onwards, distal serrations are present, and there is a very slight crown-root constriction visible in the middle maxillary teeth onwards. In the dentary, there is a marked variation in tooth morphology throughout the tooth row; the anterior dentary teeth are unserrated and moderately recurved, with a subtle crown-root constriction. The posterior dentary teeth bear a stronger crown-root constriction, which is a trait diagnostic for *Microraptor*; however, both the mesial and distal carinae of each tooth are serrated, in contrast to *Microraptor* in which only the posterior distal carinae are serrated. This new specimen reveals the breadth of dental variation in a single individual, thus

establishing a framework for understanding the range of intraspecific morphological variation possible within microraptorines and informing future phylogenetic analyses. This data will also assist in the identification of indeterminate shed teeth in microfossil assemblages, filling the gaps in our knowledge of this poorly known group in North America as well as expanding its known temporal and geographic range.

Funding Sources NSERC Discovery Grant to DCE (RGPIN-2018-06788), NSERC Discovery Grant to RRR; University of Toronto to RRR.

Technical Session - New Methods (Thursday, November 3, 2022, 10:15 AM)

MATCHING MORPHOLOGICAL CHARACTERS OF FOOTPRINTS AND SKELETONS IN THE LIGHT OF EARLY TETRAPOD EVOLUTION: EXAMPLES FROM THE BROMACKER LOCALITY (GERMANY, EARLY PERMIAN)

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Well-preserved tetrapod footprints are an invaluable source of information on the trackmaker anatomy and locomotion. In this study, we compared morphological features of the ichnotaxa *Tambachichnium* and *Dimetropus* with articulated postcranial material of their supposed producers. All the material comes from the early Permian Bromacker locality of Germany, unique for the exceptional preservation of both tracks and skeletons. A pes and a manus of the varanopid *Tambacarnifex*, two pedes and a manus of the caseid *Martensius* and a pes of the sphenacodontid *Dimetrodon* have been CT-scanned and segmented to study their morphology using the resulting 3D models. Results indicate a wedge-shape morphology of the tarsal elements and overlapping of the metatarsals in *Tambacarnifex*, features consistent with the digitigrade footprints and overlapping digit impressions in *Tambachichnium*. *Martensius* and *Dimetrodon* are instead characterised by vertical contacts between tarsal and carpal elements, consistent with the plantigrade observed in *Dimetropus*. Moreover, the distal part of phalanges overlaps the proximal part of the following phalanges, consistent with an arch-like arrangement of digits, the digital arcade. This feature is in agreement with the paw-like impressions observed in *Dimetropus*. Interestingly, the features observed in both the varanopid skeletons and tracks were also observed in diapsid skeletons such as *Petrolacosaurus* and diapsid tracks such as *Dromopus*, thus potentially supporting a phylogenetic placement of varanopids within diapsids. Further work is necessary to define these morphological characters to be used in a phylogenetic study, which may help answering the question of the placement of varanopids within either Synapsida or Diapsida.

Keywords: varanopids, synapsids, footprints, postcranium, Cisuralian

Funding Sources German Federal Ministry of Education and Research (BMBF)

Technical Session 8: Evolutionary Developmental Biology (Thursday, November 3, 2022, 1:45 PM)

GRABBING EVOLUTION BY THE THROAT: THE ROLE OF NECK-FORELIMB INTEGRATION IN AVIAN EVOLUTION

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Avian evolution is characterised by key innovations such as the evolution of powered flight, an edentulous beak, and changes in brain anatomy. Yet radical shifts in morphology do not exist in isolation, and these adaptations can impose negative effects, one such example being the forelimb's loss of grasping capability as the hand became the wing. Prior work has posited that the long and flexible neck of birds acts as a 'surrogate forelimb', positioning the beak and providing retraction forces able to manipulate surrounding environment. However, this relationship between the neck and forelimb of birds has never been formally tested. Here, we use 3D geometric morphometrics combined with a phylogenetic comparative framework to test the relationship between cervical morphology and other anatomical modules (the head and forelimb), and to assess the effect of body size and ecological parameters (diet and foraging style) in 110 extant avian species. Results from a phylogenetic two-block partial least-squares analysis indicate that, across the entire neck, vertebral morphology is highly integrated with both total forelimb length and individual forelimb bone length (R PLS = 0.78–0.81, $p = 0.001$). An increase in forelimb length is associated with features linked with an increase in range of motion (centrum length) and larger attachment sites for long dorsal musculature (neural spine size and robustness). The relationship between head mass and cervical morphology is weaker (R PLS = 0.59) and is non-significant ($p = 0.15$). We used phylogenetic MANOVA to assess the relationship between vertebral morphology and body mass, as well as the effect of ecological parameters. Across all cervical vertebra, body mass (R=0.027, $p=0.039$) and foraging style (R=0.138, $p=0.011$) had a significant but weak effect on vertebral morphology. Taken together, these results indicate that the neck and forelimb are tightly integrated in modern birds. As multiple muscles of the pectoral girdle attach to the neck, the integration recovered here is a functional integration between cervical and pectoral modules. Many of these muscles are associated with flight (e.g., mm. latissimus dorsi and mm. rhomboideus), and, as such, we propose that neck evolution is an important facet of flight evolution in birds. This work also highlights the need for evolutionary innovations to be

investigated more holistically, to understand how the vertebrate body adapts to the emergence of these innovations.

Funding Sources Leverhulme Trust Research Project Grant

Virtual Posters

THREE-DIMENSIONAL MAXILLARY CANAL RECONSTRUCTION IN *COTYLORHYNCHUS ROMERI* (SYNAPSIDA: CASEIDAE) CLARIFIES THE BASAL SYNAPSID CONDITION

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The maxillary canal is a bony tube that carries the maxillary branch of the trigeminal nerve and runs within the maxilla parallel to the tooth row in Permo-Triassic synapsids. The maxillary canal was previously reconstructed in an ophiacodontid and a varanopid but in no other ‘pelycosaur’ grade synapsids. The branching morphology of the maxillary canal in varanopids has been used as a character that supports their placement within Synapsida, but the lack of maxillary canal reconstructions for several other major clades typically classified as pelycosaur-grade synapsids hinders these comparisons and understanding of the basal state of this character within Synapsida.

Here, we reconstruct the maxillary canal of *Cotylorhynchus romeri*, a large terrestrial herbivorous caseid from the Lower Permian Hennessey Formation of Oklahoma, well known for its disproportionately small head compared to its large body. As one of the earliest diverging clades of synapsids, caseids are a good study system for understanding the primitive morphology of the maxillary canal. A complete skull of *C. romeri* (OMNH 4329) was scanned with computed tomography (CT), and we manually segmented the maxillary canal using Avizo 2020.1.

In this specimen, the maxillary canal is similar to those previously described in an ophiacodontid, a varanopid, and in early therapsids. The maxillary canal ramifies into the anterior, anterolateral, anterodorsal, and lateral directions within the maxilla, which follows the synapsid condition and is not a simple tubular structure like in diapsids. One of the branches, the external nasal canal, opens into multiple external foramina.

Through reconstructing the maxillary canal of *Cotylorhynchus*, we show that *Cotylorhynchus* likely had extensive facial sensory innervation, comparable to therapsids and mammals. Maxillary canal morphology has been used as a phylogenetic character to distinguish diapsids and synapsids,

and this work adds more evidence that a highly branched maxillary canal was ancestral for Synapsida, including caseids.

Funding Sources Oklahoma State University Center for Health Sciences

Technical Session 5: Amphibians & Early Reptiles (Thursday, November 3, 2022, 8:00 AM)

***CHINLESTEGOPHIS* AND THE ORIGIN OF CAECILIANS (GYMNOPHIONA, LISSAMPHIBIA): A CASE STUDY IN PHYLOGENETICS**

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The description of the small Late Triassic temnospondyl *Chinlestegophis* five years ago ushered in a new age in the study of the origins of the extant amphibian clades: together with the fragmentary *Rileymillerus* and other “laticopids” that have been announced at recent conferences, *Chinlestegophis* was argued to link the extant caecilians to the Permo-Triassic stereospondyl temnospondyls rather than to frogs and salamanders (and through them to amphibamiform temnospondyls or to brachystelechid and lysorophian “lepospondyls”). We review previously published and newly discovered problems with the comparative description of *Chinlestegophis* and with the accompanying phylogenetic analyses. Most of the features previously interpreted as shared by caecilians, *Chinlestegophis* and/or other stereospondyls have different distributions, some of which require changes to the matrices for phylogenetic analysis. We also find no evidence for an incipient tentacular sulcus in *Chinlestegophis*, and note its unreduced ribs, dermal shoulder girdle and ulna as well as its vertebrae that are unlike in any modern amphibians. Further, the original matrices contain misscores accreted over more than a decade – many already addressed in publications by other authors during that time – that likewise influence the results, and some features are coded as multiple redundant characters: the double toothrow of *Chinlestegophis*, other stereospondyls and caecilians is represented as seven characters. The original analysis results, which are much less resolved than reported at first, are very vulnerable to small changes to the taxon sample, limited revisions of irreproducible scores, and ordering the most obviously clinal characters; any such changes remove *Chinlestegophis* from Lissamphibia. We welcome further research on “laticopids”, a fascinating clade of dwarf stereospondyls unable to live in all but the moistest air (on account of the lateral-line organ) but found in burrows. Concerning phylogenetics, we reiterate that the majority-rule consensus is not a useful representation of the result of a parsimony analysis, and that not all issues

with Bayesian analysis of matrices with missing data have been solved; but most importantly, matrix quality remains paramount in phylogenetic analysis. This concerns typographic errors, misinterpretations of published literature, redundant characters, characters that represent two or more independently varying features, and inconsistencies in scoring.

Virtual Posters

THE FIRST DINOSAUR SKELETAL FOSSILS FROM THE KAYENTA FORMATION OF UTAH

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The silty facies of the Kayenta Formation (Lower Jurassic) in north-central Arizona preserve one of the most significant post-mass extinction terrestrial tetrapod assemblages in the world. Sites in the silty facies like Gold Spring on Ward Terrace, Navajo Nation are famous for Early Jurassic neotheropod, sauropodomorph, and thyreophoran dinosaurs, pterosaurs, sphenosuchian, protosuchid, and goniopholidid crocodylomorphs, turtles, tritylodontid and mammaliaform cynodonts, rhynchocephalians, and anuran and caecilian lissamphibians. However, the tetrapod fossil record of the typical fluvial sandstone facies of the Kayenta Formation is comparably depauperate, only preserving incomplete skeletons of a tritylodontid and a crocodylomorph in northeastern Arizona.

Here we report fragmentary elements from a single individual of a saurischian dinosaur collected from the thicker interbedded mudstone-sandstone facies of the Kayenta Formation of the northern Paradox Basin around Arches National Park in eastern Utah during a 2011 National Park Service-Utah Geological Service paleontological inventory. The elements include vertebral fragments, the distal ends of a radius, femur and metapodial, part of the shaft of a fibula, and the proximal ends of metatarsals III and IV. The size and shape of the proximal ends of the metatarsals compare more favorably to theropods like *Dilophosaurus wetherilli* than sauropodomorphs like *Sarahsaurus aurifontanalis*, the two larger-bodied saurischians known from the silty facies of the formation.

These dinosaur body fossils represent the first reported from the Kayenta Formation of Utah and are an important faunal link between the sandier facies of the Kayenta Formation in eastern Utah and the relatively fossil-rich silty facies of the formation in Arizona. Although a clear preservation bias exists between the depositional regimes of the formation, there is a potential for more tetrapod remains to be found in these more complex, possibly salt tectonics-controlled facies from the northern part of the Paradox Basin, which experienced drying earlier as the North American plate moved into the arid belt during the latest Triassic and Early Jurassic. These fossils also highlight the importance of collaborative paleontological inventories in National Park Service units for preserving

natural resources and acting as natural labs for scientific research and discovery.

Funding Sources Utah Geological Survey; National Park Service, Arches National Park, Petrified Forest National Park.

Technical Session 2: Paleoecology (Wednesday, November 2, 2022, 8:00 AM)

POLAR DINOSAUR TRACKS GREAT AND SMALL IN THE EARLY CRETACEOUS WONTHAGGI FORMATION OF VICTORIA, AUSTRALIA

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The Wonthaggi Formation (Valanginian-Aptian) in Victoria, Australia has the oldest polar dinosaur body fossils in Australia, consisting of a diverse assemblage of ornithischians and theropods. However, most dinosaur bones and teeth are preserved as disarticulated elements and were likely transported by seasonal discharge in rift valleys before deposition in fluvial channels. In contrast, footprints provide direct evidence of dinosaurs living in nearby environments. Thus we are pleased to report the recent discovery of nearly fifty (n = 47) tridactyl dinosaur tracks from Barremian-Aptian (128-120 Ma) strata of the Wonthaggi Formation near Inverloch, Victoria. Almost all tracks are isolated impressions in marine-platform exposures of overbank and floodplain facies, but clusters on bedding planes show that multiple dinosaurs were in the same areas at about the same times. Based on track forms, more than 90% of tracks found thus far were made by theropods, with only a few small ornithopods represented. This abundance of theropod tracks versus those of ornithopods contrasts starkly with Wonthaggi body fossils, which are dominated by ornithopods. Tracks fall into three main size ranges, “small” (5-12 cm long), “medium” (18-34 cm long), and “large” (35-47 cm long). Small tracks correspond to hip heights of 20-48 cm for their theropod and ornithopod makers, whereas medium and large tracks (all theropods) indicate hip heights of 0.7-1.9 m. Two specimens (44 and 47 cm long) are the biggest known Cretaceous theropod footprints in Victoria, representing sizes akin to the megaraptoran *Australovenator*. Such tracks thus affirm the presence of large polar theropods previously inferred from scanty skeletal material. The smallest footprints indicate either minute adults or juveniles of larger species, as documented in some dinosaur body fossils (e.g., *Timimus*, *Atlascopcosaurus*, *Qantassaurus*). If smaller tracks are those of juveniles, then some dinosaurs probably nested and raised their young in

these circumpolar environments, rather than seasonally migrating. Moreover, because tracks were preserved in floodplains adjacent to fluvial channels, they were likely made by dinosaurs traveling through those environments after spring-thaw flooding, such as during polar summers. In summary, these trace fossils expand the once-limited track record in the Wonthaggi Formation, while also corroborating a dinosaurian presence in the same places with skeletal material.

Technical Session 14: Squamates & Turtles (Friday, November 4, 2022, 1:45 PM)

DETERMINING THE AFFINITY OF FOSSIL XANTUSIID JAWS WITH IMPLICATIONS FOR POST K-PG SQUAMATE DIVERSITY

Martinez, Selena A.

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Xantusiidae (night lizards) is a lizard clade native to the southwestern United States and Baja California, Cuba, and Central America. There are three extant clades, *Cricosaura typica* (Cuban night lizard), *Xantusia* (desert night lizard), and *Lepidophyma* (tropical night lizard), and multiple fossil members have been identified. “*Palaeoxantusia*” is a wastebasket taxon of Paleogene pan-xantusiids, though there is debate regarding the species of these fossils. Further uncovering the diversity of “*Palaeoxantusia*” is important for understanding why this clade was so successful following the extinction. Xantusiids are well-known for their microhabitat specialization (inhabiting rock crevices, living in decaying plants), and this specialization has implications for their survival, and resultant speciation, of the Cretaceous-Paleogene Mass Extinction Event. Two-dimensional (2D) geometric morphometrics was used to determine intra- versus interspecies variation among Xantusiidae. This method was tested on extant xantusiids and then applied to fossil specimens. Individuals were found to cluster by clade, and by fossil or extant status, except in the case of outliers, such as *Xantusia riversiana*, and the species complex *Xantusia vigilis*. Fossil and extant taxa occupy discrete regions of morphospace, suggesting that these animals may have occupied disparate ecological niches in life. Fossil xantusiids and the extant clade *Lepidophyma* were found to show morphologies consistent with generalist ecology. The modern clade *Xantusia* was shown to possess specialized morphologies that may be suited for their crevice-dwelling ecologies. Fossil taxa were found to not occupy this region of morphospace, suggesting that extinct xantusiids had not yet acquired many of the morphological adaptations associated with crevice-dwelling microhabitat occupation. Further, based on the ecological and climatic upheaval associated with the K-Pg extinction, it is likely that stem xantusiids were limited in their niche occupation, compared to that of modern xantusiids.

Funding Sources Davenport College Mellon Senior Research Grant; Yale University Department of Earth & Planetary Sciences

Virtual Posters

COMPARATIVE MORPHOMETRIC STUDY OF PROBOSCIDEAN DENTITION FROM THE APAK MEMBER OF THE NACHUKUI FORMATION AT LOTHAGAM, KENYA

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The early Pliocene interval of the Apak Member at Lothagam, Kenya, documents significant faunal turnover. During this time, wooded savannas and savanna woodlands expanded in eastern Africa, and elephants consequently evolved to better adapt to grazing. It is also the time of the first appearance of the hominin *Australopithecus*, many modern antelope tribes, and new horses, hippos, and pigs. Proboscidean species previously identified from the Apak Member include *Deinotherium bozasi*, *Anancus kenyensis*, *Stegotetrabelodon orbus*, cf. *Elephas ekorensis*? aff. *Loxodonta*, *Loxodonta exoptata*, and several unidentified elephantids. This study compiled a database of these fossils and undescribed specimens for comparison with late Miocene Lothagam proboscideans and proboscidean assemblages from nearby sites of similar age, particularly those from other sites in or near Turkana Basin (including Kanapoi, Ileret, and South Turkwel). Our objectives were to improve our understanding of the transition from archaic to more advanced proboscideans in Africa and proboscidean cohorts' role in shaping ecosystem changes. This study focused on measurements and morphological descriptions of all proboscidean teeth comprising the Apak Member assemblage, including 15 previously studied and 11 undescribed proboscidean specimens at the National Museum of Kenya. Essential features studied include the relative height of the crown (hypsodonty index), which is important for grazing animals, and the number of molar plates, which increase in more advanced proboscideans. Our results meaningfully revise and increase the taxonomic composition of proboscideans in the Apak sample, revealing a complex relay of primitive to more derived elephants during the early Pliocene, that documents the adaptive response to increased competition among mammals for grazing resources.

Technical Session 9: Mammals (Friday, November 4, 2022, 8:00 AM)

UNIQUE ZYGOMATIC ARCH COMPLEXES IN THE LATE PLEISTOCENE-EARLY HOLOCENE GROUND SLOTH *NEOCNUS* FROM THE DOMINICAN REPUBLIC

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A number of specimens of the extinct sloth genus *Neocnus* recovered from an underwater cavern in the northwestern Altagracia Province of the Dominican Republic exhibit a unique zygomatic arch complex. Sloths typically lack a complete and bony zygomatic arch, with completion typically formed by a bridging zygomatic arch ligament. Secondary completion of the arch occurs in the larger of extinct sloth taxa, wherein the jugal and temporal bones make physical contact without the ligament. In these *Neocnus* specimens, the arch consists of the jugal anteriorly fused to the maxilla and the zygomatic arch ligament fully ossified between the jugal and the zygomatic process of the temporal bone. Evidence of the novel ossification is exhibited by a number of adult individuals, as well as multiple juveniles. This occurrence is also unexpected as *Neocnus* individuals are 40 times smaller than the next sloth genus with a secondarily completed arch. The morphology of the jugal differs from other *Neocnus* species by having a larger and fused contact with the maxilla, similar to that seen in *Acratocnus*. This and other novel features of the jugal and zygomatic from the other Hispaniola species of *Neocnus* may indicate the existence of a new species.

Virtual Posters

FIRST RHAETIAN-AGED ICHTHYOSAUR FROM THE PARDONET FORMATION OF BRITISH COLUMBIA, CANADA

McBride, Brady A.¹, Lei, Jerry², Zonneveld, John-Paul³, Caruthers, Andrew H.⁴, Arbour, Victoria¹

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Numerous Carnian and Norian ichthyosaurs have been collected from Pardonet Formation exposures around Williston Lake by the Royal Ontario Museum during the 1980s and from the Sikanni Chief River by the Royal Tyrrell Museum in the 1990s. Here we describe a new Rhaetian ichthyosaur occurrence from Pardonet Creek, on the southern shore of the eastern branch of Williston Lake. Abundant fragments of one or more ichthyosaurs were found weathering out from a bone bed positioned 6.0 m stratigraphically above the last occurrence datum of *Monotis* bivalves, which is a commonly utilized proxy approximating the Norian –

Rhaetian boundary. The ammonoid *Cladiscites tornatus* was also identified at this bone bed, reaffirming Rhaetian age.

The new material consists of a forefin, a partial sclerotic ring, six teeth/tooth impressions, cranial elements, and unidentified fragments. The forefin consists of at least four digits with distinct hexagonal phalanges, and measures at least 17.7 cm wide laterally. Based on the number of digits as well as the distinct morphology and mosaic pattern of the phalanges, the forefin is most similar to *Macgowania janiceps* as well as other species within the clade Parvipelvia. This arrangement differs from other Triassic ichthyosaurs such as the shastasaurids and *Callawayia neoscapularis*, which typically have a maximum of three digits. The morphology and pattern also differentiate this forefin from the hourglass-shaped phalanges of more basal ichthyosaurs like *Mixosaurus*. The absence of a humerus in this specimen precludes more specific identification.

Along with other parvipelvians discovered from the Pardonet formation, the forefin specimen shares more characteristics with Jurassic ichthyosaurs than with most Triassic forms. The end of the Triassic period is marked by an extinction event that resulted in a loss of biodiversity, particularly in marine environments, and ichthyosaurs underwent an extreme evolutionary bottleneck during this transition resulting in the abrupt loss of the shastasaur lineage in the Late Triassic. Parvipelvians were the only clade of ichthyosaurs to survive the extinction, giving rise to groups including ophthalmosaurs that survived later into the Mesozoic. Rhaetian ichthyosaurs are rare, and a new locality with Jurassic-like forms has the potential to shed light on the timing and nature of the Late Triassic ichthyosaur bottleneck event.

Funding Sources Natural Sciences and Engineering Research Council

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

ASSESSING TAPHONOMIC ACTIVITY AMONG VERTEBRATE REMAINS FROM TWO UPPER JURASSIC MORRISON FORMATION FOSSIL SITES: BONE CABIN AND MYGATT-MOORE QUARRIES

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Bone surface modifications (BSMs) on vertebrate remains provide critical data on taphonomic and paleoecologic activity. A recent large-scale analysis of BSM data from the Mygatt-Moore Quarry (MMQ) in Colorado (Morrison Formation) showed a high frequency of BSMs among the elements in the assemblage. However, large-scale taphonomic surveys are rare in the published literature and a reasonable

correlate study for comparison was unavailable. Here, we present results of a BSM survey of fossil material from Bone Cabin Quarry (BCQ) (Morrison Formation) housed at the Museums of Western Colorado. Frequencies of BSMs were compared between surveys in two metrics: 1) percentage of altered elements, and 2) percentage of altered surface area. To estimate altered bone surface area, we calculated BSM frequencies using a 2.0 cm² digital grid system, which allowed us to compare specimens and samples that vary in size, shape, completeness, and/or field collection technique. In this system, we overlaid a minimum of two images per specimen with a 2.0 cm² digital grid. Grid squares were assigned unique values and frequencies were calculated for BSMs present on preserved cortical tissue. Results show higher frequency of BSMs among the grids of the MMQ sample than BCQ. This is echoed by an order of magnitude lower frequency of modified elements in the BCQ survey. The disparity of BSM frequencies, and thus inferred taphonomic activity, at the two Morrison sites may be due to a difference in depositional regime. Fossils from BCQ are preserved in a coarse lenticular sandstone from the Lake Como Member, which is interpreted to represent a high-energy channel deposit. Whereas the MMQ is a relatively low-energy mudstone to siltstone unit in the stratigraphically higher Brushy Basin Member, which is interpreted as an attritional overbank deposit. These depositional systems may have included vastly different burial rates for large vertebrate remains, creating unequal availability for taphonomic agents to modify bone surfaces at the sites. The higher frequencies of insect and vertebrate feeding traces on the material from the MMQ supports a longer residence time for bones at that site. By calculating BSM frequencies as both a metric of the number of elements showing modifications and as an estimation of worked surface area, a more practical comparison of taphonomic activity between disparate fossil sites, depositional regimes, and collection protocols is possible.

Technical Session 4: Paleobiogeography (Wednesday, November 2, 2022, 1:45 PM)

THERE AND BACK AGAIN? PREDICTING MARSUPIAL DISPERSAL ACROSS PALAEOGENE GONDWANA USING THE NICHE OF EXTANT TAXA

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Marsupials seem to have originated in South America, with some groups later travelling to Australasia via Antarctica in the late Cretaceous/Palaeogene (a period when the three continents were connected to form Gondwana). However, given the limitations of the fossil record, it is unclear which groups undertook such a dispersal, and if any Australasian marsupial clades ever dispersed back to South America. Our understanding of this significant biogeographical event is further complicated by the break-up of Gondwana and the

potential dispersal barrier of Antarctic mountainous regions.

We propose that by projecting the ecological niches of extant marsupial groups onto palaeo-climate reconstructions, we can model the distribution of suitable habitat across Palaeogene Gondwana, and thus predict which groups could travel between continents. We compiled occurrence datasets representing every living marsupial species and tested the statistical quality of 1054 ecological niche models per group. The best of these models indicate that many Australasian marsupial clades, as well as the South American shrew opossums, may have been able to disperse across Gondwana via 'corridors' of suitable habitat, matching some palaeontological findings. Interestingly, despite being a group associated with the temperate rainforests that characterised Palaeogene Gondwana, the microbiotheres see less conclusive results. This could be because the distribution of microbiotheres relates more to the presence of key plant taxa, and less to climate. Ultimately, our models offer a new insight into the historical biogeography and evolutionary history of marsupials, especially when compared to data from the fossil record and beyond.

Funding Sources NERC (Natural Environment Research Council)/St Cross College, Oxford

Symposium: International Community Connections (Wednesday, November 2, 2022, 1:45 PM)

COLLABORATIVE LEARNING: CO-DEVELOPMENT OF AN INTERACTIVE PALEONTOLOGY-FOCUSED SCHOOL PROGRAM BY THE SMITHSONIAN INSTITUTION AND THE NATIONAL MUSEUMS OF KENYA

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Here we present the processes of planning, developing, testing, and executing a collaboratively built museum learning program in human evolutionary studies by The National Museums of Kenya, Nairobi (NMK), the Smithsonian National Museum of Natural History (NMNH) Human Origins Program (HOP), and the Smithsonian Office of International Relations (OIR) - together, the Smithsonian Institution (SI). Based on SI and HOP's expertise and the NMK collections and Kenyan curriculum, the team created a human evolution centered program. Prompted by observation of a forensic anthropology school program in the NMNH Q²rius learning space, we hypothesized that a case study format would

provide the most utility and flexibility in incorporating multiple lines of scientific inquiry. Centered on the Homo erectus fossil KNM-WT 15000, nicknamed “Turkana Boy,” this learning activity included five stations dedicated to exploring different lines of evidence in human evolutionary sciences, all relating back to the life and death of Turkana Boy. Pilot testing of the first station, “Human Family Tree,” at NMNH in October 2019 resulted in positive feedback with 80-100% of participants (n=17 teen volunteers) reporting the activity to be fun, clear, and understandable. Engagement with the scientific process was rated at 4.3 out of 5 on a Likert scale. Pilot testing of the same station at NMK in January 2020 resulted in similar feedback with participants expressing engagement in the scientific process at an average of 4.9 out of 5 on a Likert scale (n=14 museum educators). Subsequently developed stations include “Bipedalism,” “Diet and Environment,” “Stone Tools,” and “Social Life and Intelligence.” This program introduces a new type of inquiry-based program to NMK, expanding the types of visitor engagement and experiences offered. The skills and confidence acquired by the NMK Education team during our collaborative program development to date inspired them to launch their first ever online program during COVID, and the online program we developed was adapted for a new online school program at NMNH. We plan to continue this collaboration in the future, including securing funding to provide casts and materials to implement and evaluate the in-person school program, supporting learning exchange for members of both institutions, and expanding the collaboration to regional museums in Kenya.

Technical Session 9: Mammals (Friday, November 4, 2022, 8:00 AM)

INSIGHTS FROM AN UNDERSTUDIED MAMMAL SITE FROM THE MID-PALEOCENE (TORREJONIAN) OF SOUTHEASTERN MONTANA

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The mid-Paleocene (ca. 63–58 Ma) is a relatively understudied period of mammalian evolution in comparison to the abundance of work focusing on early Paleocene mammalian recovery post-K-Pg mass extinction and the impacts of the Paleocene-Eocene Thermal Maximum (PETM) on mammalian diversity at the end-Paleocene. Yet, more attention to the mid-Paleocene is warranted given that continental mammalian generic richness peaks and then steeply declines across the Torrejonian-Tiffanian boundary (~61 Ma) coeval with changes to community structure. A shift to a more temperate climate has been implicated as a driver of declining diversity during this interval, but paleoclimate data reveals global cooling didn't occur until later (~59 Ma). In Montana, the Crazy

Mountains Basin region preserves several stratigraphically-superimposed sites spanning the mid-Torrejonian (To2) to mid-Tiffanian (Ti3), but critically lacks any representing the latest Torrejonian (To3) faunal zone, inhibiting efforts to study the Torrejonian-Tiffanian boundary in greater detail. To the southeast, in Carter County, several sites—Medicine Rocks I-III and the Mehling Site—preserve putative To3 mammal assemblages. Previous research has identified at least two species of primates (*Pronothodectes matthewi* and *Elphidotarsius cf. E. florencae*) and six species of multituberculates (*Baiotomeus lamberti*, *Mesodma pygmaea*, *Neoplagiaulax nelsoni*, *Parectypodus sylviae*, *Ptilodus wyomingensis*, and the tentatively referred *Ptilodus titanus*) from the Medicine Rocks localities, whereas only multituberculates (*P. wyomingensis* and *B. lambertii*) have been described from the nearby Mehling Site. Here, we present the results of an ongoing faunal analysis of the Mehling Site based on an initial sample of at least 110 isolated mammal teeth and six jaws with teeth. The majority of specimens are eutherian mammals (80%) and the rest are multituberculates; no metatherians have been identified so far. This work expands the known fauna to include representatives of Carnivora, Cimolesta, Dermoptera, Eulipotyphla, Leptictida, Procreodi, ‘Archaic ungulates,’ and possibly Creodonta. We assess the assignment of the Mehling Site to To3 age and compare the Mehling local fauna with contemporaneous local faunas in western North America to assess whether the diversity and/or community structure differs from the broader continental patterns.

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

NEW RECORD OF NON-AVIAN DINOSAURS FROM THE GAFSA BASIN, WESTERN-CENTRAL TUNISIA

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A systematic examination of fossil vertebrate remains previously displayed at the former Mélaoui Museum in the Gafsa Governorate, west-central Tunisia, has revealed the first definite record of non-avian dinosaurs from the Gafsa Basin. The specimens are diagnosed by partially complete limb-bones and isolated vertebrae that belong to two distinct, but undetermined taxa. Yet, based on the morphology, we tentatively attribute the limb-bones to a sauropod-like animal. Most documentation associated with the specimens, including their source, was destroyed in the fire that destroyed the Mélaoui Museum during the Arab Spring uprising in 2011. In order to narrow-down their potential source of origin, we conducted several analyses including x-ray diffractometry (XRD) and polarized-light microscopy on petrographic thin-sections taken from both specimens. The results show that

well-crystallized francolite and hematite are the major components as reflected in the diffractograms. Similar geochemical profiles suggest that both specimens likely come from the same geological unit and are indicative of fossilization within a continental setting. Furthermore, comparison with existing specimens from late Mesozoic fossil sites in Tunisia suggests that these specimens found in the Gafsa Basin may have originated from central Tunisia island or Jeffara island, where dinosaurs flourished during the Cretaceous. Although our results are preliminary, they add to the existing data on Gondwanan dinosaurs. Future fieldwork will reveal new findings and confirm the provenance of the specimens reported here.

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

MEASUREMENT PROTOCOL INFLUENCES INTRASPECIFIC MOLAR VARIATION IN MODERN AND FOSSIL RODENTS

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The inhibitory cascade (IC) model of dental development explains molar area variation across mammalian orders and links morphology to both dietary ecology and evolutionary history. Modern rodent species span a range of dental phenotypes consistent with the IC model, and previous work has characterized extinct rodent dental variation as broadly consistent with the IC model. Our prior work identified high intraspecific variation in 46 species of early North American Eocene-Oligocene rodents relative to modern rodents. High intraspecific variation in fossil taxa has been attributed to taxonomic lumping among fossil species, time averaging of phenotypically plastic populations, or increased morphological plasticity in more basal taxa. Previous approaches have, however, compared data collected by different observers and using different methods (e.g., camera photos and images of microCT-derived models). Here, we re-evaluate molar area ratios collected using different methods (published images, camera-based photographs, and microCT-based models) to characterize how intraspecific variation of early North American fossil rodents compares to modern populations and how image acquisition method affects outline-based measurements.

We assessed the intraspecific coefficient of variation (CV) of molar area ratios using both microCT-derived models (10-20 individuals for three species) and high-resolution macro lens images of North American rodent species (15 individuals each for nine species) in ImageJ. Preliminary data show that the intraspecific CVs calculated from camera imagery are markedly higher than those calculated from microCT images from the same species that were aligned to the occlusal plane

(e.g., m2/m1 5.77 versus 4.85 and m3/m1 13.24 versus 8.96 for *Onychomys leucogaster*). However, linear measurements acquired from photographs were just as accurate as microCT data. This suggests that the angular offset from the occlusal plane of tooth row images can have a larger than expected impact on variation in measured molar areas. Thus, we suggest that best practices should compare variation using the same methodology (with microCT-derived images preferred for small specimens). The specimens we measured from camera photos are slated for microCT-scanning in the near future, which will allow the direct comparison of CVs measured at different canting angles from the same specimens.

Technical Session 14: Squamates & Turtles (Friday, November 4, 2022, 1:45 PM)

ANALYSIS OF A STEM-GEKKOTAN FROM THE MORRISON FORMATION PLACES THE SOLNHOFEN SQUAMATES ON THE TREE OF LIFE

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The Late Jurassic Bavarian Solnhofen limestone is a Konservat-Lagerstätten known for its exceptional preservation of multiple species of marine and terrestrial animals. It is most famous for the pan-avian *Archaeopteryx lithographica*. However, many other reptiles are present, including six pan-squamates: *Eichstaettisaurus schroderi*, *Bavarisaurus macrodactylus*, *Schoenesmahl dyspepsia*, *Palaeolacerta bavarica*, *Ardeosaurus brevipes*, and *A. digitellus*. Just as *A. lithographica* yields insights into a key phase of bird evolution, these species provide a view of Mesozoic squamates shortly after their estimated Early to Mid-Jurassic backbone divergences.

While investigating the affinity of a squamate from the Morrison Formation, we incorporated these Solnhofen squamates into a large dataset (637 characters x 154 taxa). We ran several analyses, including maximum and implied-weights parsimony (K=12, 3, 6, and 24), unconstrained and constrained to a molecular topology, with generally consistent placements of Solnhofen taxa at key basal points on the squamate tree.

B. macrodactylus is invariably on the squamate stem, excluded from *Squamata* by lacking paired frontals, a squamosal flush with the parietal, and an expanded clavicle with molecular constraints, and lacking haemal arch pedicles without them. Nearly all analyses place both species of *Ardeosaurus* with the Morrison taxon at the base of *Pan-Gekkota*, sharing paired premaxillae, a midline postparietal projection, and total loss of the squamosal ascending process. *E. schroderi* is always a stem gekkotan, supported by the shape of the frontal subolfactory processes and a high

maxillary tooth count.

We find alternative positions for the more fragmentary *S. dyspepsia*, including on the gekkotan and squamate stems in unconstrained trees, and as sister to lacertoids + toxicoferans in constrained ones. Most notably, *P. bavarica* is consistently a stem-iguanian, supported by the pineal foramen position and caudal autotomic septa posterior to the caudal ribs. *P. bavarica* would thus be the first confirmed Jurassic stem iguanian, as *Bharatagama rebbanensis* of India is likely a rhynchocephalian, not a pan-acrodont squamate. Our results show that these Jurassic squamates comprise a menagerie of important early members of several major pan-squamate clades. Thus, they may be key to understanding early squamate evolution, and to resolving ongoing conflicts between morphological and molecular hypotheses of squamate phylogeny.

Virtual Posters

REVALUATING THE LEPTOCERATOPSID (CERATOPSIA) RECORD FROM THE CAMPANIAN OF ALBERTA, CANADA

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With the exception of *Leptoceratops* from the latest Cretaceous, leptoceratopsid ceratopsians are known from relatively few complete specimens. As such, their early evolutionary history is poorly understood. The discovery of TMP 2011.053.0027, an isolated right leptoceratopsid frontal from the lower unit of the Oldman Formation (~79 Ma) fills in a significant time gap in the Albertan leptoceratopsid record between the occurrence of the oldest known leptoceratopsid, *Gryphoceratops* from the Santonian Milk River Fm (~84 Ma), and TMP 1987.089.0008, an isolated frontal from the upper unit of the Oldman Fm (~77 Ma), as well as providing additional data to test the latter's previous referral to *Prenoceratops* sp.

The large caudolateral process and the relatively deep frontal depression of TMP 2011.053.0027 identifies it as a leptoceratopsid. Re-examination of all leptoceratopsid frontal characters, including the description of new frontals (e.g., ROMVP66302.1) from the holotype *Prenoceratops* bonebed in the Two Medicine Formation of Montana, confirms that the shape of the transverse ridge demarcating the anterior margin of the frontal depression is highly variable, ranging from straight to deeply curved, thus rendering the character phylogenetically uninformative (a straight margin had previously been used as a synapomorphy of *Prenoceratops* and *Cerasinops*). A phylogenetic analysis of TMP 2011.053.0027 failed to resolve its placement within Ceratopsia beyond Neoceratopsia indet. due to the specimen only having two phylogenetically-informative characters.

Although both TMP 2011.053.0027 and TMP 1987.089.0008 can now only be referred to Leptoceratopsidae indet., we suggest that the former may be referable to *Cerasinops* (from the Two Medicine Fm of Montana) based on the time equivalency of their localities. Similarly, TMP 1987.089.0008 may also eventually be referred to *Unescoceratops* sp. which occurs in time equivalent sediments of the Dinosaur Park Formation, with the localities for both specimens being older than the holotype *Prenoceratops* bonebed.

Leptoceratopsids continue to be an enigmatic component of the Santonian and Campanian fossil record of Alberta and equivalent beds in the United States, but key features of their skull (e.g., the distinctly deep lower jaw and the relatively deep frontal depression) appear to have been established early in their evolutionary history.

Technical Session 3: Marine Reptiles (Wednesday, November 2, 2022, 8:00 AM)

ONTOGENETIC VARIATION IN THE CRANIUM OF MIXOSAURUS CORNALIANUS SHOWS DEVELOPMENTAL TRANSITION OVER ICHTHYOSAUR EVOLUTIONARY HISTORY

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Mixosauridae is a clade of early ichthyosauromorphs known from Middle Triassic localities worldwide. Its early branching phylogenetic position makes it a key taxon for understanding ichthyosaur evolution. Despite the many specimens available, assessment of the *Mixosaurus* cranium has been difficult, mainly due to the combination of its complex three-dimensional morphology and diagenetic flattening of specimens. Moreover, ontogenetic variability of the cranium is poorly understood in the group. We qualitatively studied 17 well-preserved specimens of *Mixosaurus* from the Besano Formation of Monte San Giorgio, ranging in ontogenetic age from fetuses to large adults. We used mandible length as a proxy for ontogenetic stage, with postnatal specimens ranging in size from 110 to 230 mm mandible length. Sexual maturity was present at 208 mm mandible length (smallest pregnant female). One pregnant female contained substantial fetal material, which enabled us to study a prenatal developmental stage. We were able to observe all skull roof and palatal elements in isolation, especially in disarticulated juvenile specimens. Newly observed morphological character states in the skull of *Mixosaurus* include: parietal enclosing most of the parietal foramen, elongated postfrontal forming most of orbital

roof, absence of an elongated posteromedial process of the pterygoid. The braincase and postorbital show interesting ontogenetic changes. The postorbital shows a triradiate morphology prenatally, similar to early diapsids, but different from ichthyosaurs. The basioccipital extracondylar area shows a midline furrow in early development that gradually becomes a ventral depression in adulthood. We hypothesize that this furrow relates to the onset of developing basal tubera, which are present in early diapsids, but absent in most ichthyosaurs. The exoccipital footplate is split under the hypoglossal foramen in prenatal ontogeny, showing its ossification trajectory. Both the midline furrow and the exoccipital footplate split are absent in *Stenopterygius*, showing a developmental change over phylogeny. Moreover, the parabasisphenoid shows clear clinoid processes and a mid-pharyngeal recess which are likewise present in early diapsids but absent in most ichthyosaurs. These observations indicate that *Mixosaurus* still retains ancestral morphology especially with regard to the braincase and that significant ontogenetic evolution occurred between *Mixosaurus* and *Stenopterygius*.

Technical Session 18: Birds (Saturday, November 5, 2022, 1:45 PM)

QUANTITATIVE INVESTIGATION OF MESOZOIC TOOTHED BIRD (PENGORNITHIDAE) DIET REVEALS EARLIEST EVIDENCE OF MACROCARNIVORY IN BIRDS

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Enantiornithes is the most widespread and speciose group of birds in the Mesozoic, but much of their ecology remains obscure. Their diet, in particular, remains highly speculative. Pengornithidae is one of the best-understood families within Enantiornithes due to the excellent preservation of several key specimens, and members have hypotheses of invertivory and hypocarnivory established in the literature to test. We investigated four lines of quantitative evidence to reconstruct the diet of pengornithids: body mass estimation, claw traditional morphometrics, jaw mechanical advantage, and jaw finite element analysis. We collected data for each of these lines of evidence from each applicable pengornithid and over 150 extant birds as reference taxa. All four lines of evidence could be applied to *Pengornis* and *Parapengornis*, and two could be applied to *Eopengornis*, *Yuanchuavis*, and *Chiappeavis*. Due to limited data, the diets of *Eopengornis* and *Chiappeavis* remain obscure. *Pengornis*, *Parapengornis*, and *Yuanchuavis* show adaptations for some form of carnivory, and their large (~350–500 g) adult size indicates specialization

in vertebrate prey was more likely. Thus we reject the hypotheses of invertivory and hypocarnivory for these taxa. All three birds' jaws have mechanical similarities to extant piscivores, but *Pengornis* appears to have had a more generalist diet. Also of note, *Pengornis*' talons are similar in shape and relative size to extant raptorial birds taking large prey, the earliest evidence of adaptation for this behavior in avialans. This study increases the number of quantitatively-supported Mesozoic bird diets by 20% and underscores the importance of using multiple lines of evidence for reconstructing paleodiet.

Funding Sources CVM: Postgraduate Scholarship from The University of Hong Kong, MP: RGC of HK's GRF (17120920; 17103315; 17105221) and the SLC at the Chinese University of Hong Kong.

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

COMPARISON OF MIDDLE AND LATE UINTAN (MIDDLE EOCENE) FAUNAL COMMUNITY COMPOSITION IN THE UINTA BASIN, UTAH

Miller, Emma V.¹, Stroik, Laura K.¹, Townsend, K.E. Beth², Westgate, James W.³, Murphey, Paul C.⁴, Friscia, Anthony R.⁵, Higgins, Penny⁶

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The Uinta Basin in northeastern Utah is one of the most fossiliferous middle Eocene localities in the Western Interior and preserves a stratigraphic sequence that includes the Uinta and Duchesne River Formations. Importantly, it is here that the Uintan and Duchesnean North American Land Mammal Ages (NALMAs) were first defined, and the Uinta Basin conformably records the boundary between them. Historically, fossil collection in these rock units has focused on the upper intervals of the Uinta Formation (Ui2-3 in age). However, current project goals now include an assessment of faunal change across both the Uintan-Duchesnean NALMAs and the Middle Eocene Climatic Optimum (MECO; likely in the early Duchesnean). In addition, there has been a recent emphasis on screen-washing in an effort to compensate for potential size biases against small taxa associated with surface collection.

We performed a community composition analysis of recent collections from the middle and upper Uinta Formation. Such an analysis is a prerequisite for addressing new questions pertaining to potential faunal turnover events related to the Uintan-Duchesnean boundary and MECO hyperthermal, as it provides a baseline for comparisons of faunal diversity and abundance.

Fish, reptile, and mammal specimens collected during the 2004-2021 field seasons (N=4,330) were identified to the family level and assigned to either the Ui2 (N=1,736) or Ui3 (N=1,297) sub-NALMA. Chi-square analysis indicated that the community composition of the sub-NALMAs are distinct ($P < 0.001$) and that both the Shannon and Simpson's diversity indices are higher in Ui3. Specifically, the relative abundances of primates, marsupials, eulipotyphlans, lagomorphs, and rodents increased, while those of perissodactyls, artiodactyls, and condylarths decreased, from Ui2 to Ui3. These findings are in contrast to previous assessments of faunal change at the site. These results highlight the impact and importance of screen-washing on paleocommunity reconstructions.

Funding Sources NSF-EAR 2011695, NSF-EAR 2011677, NSF-EAR 2011685, NSF-EAR 2011698

Technical Session 12: Rodents & Quaternary Mammals
(Friday, November 4, 2022, 1:45 PM)

MAMMOTH EXTINCTION HIGHLIGHTS CONTRIBUTIONS TO eDNA RECORDS BY THE DEAD AND DECAYING

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When did the Pleistocene megafauna go extinct? Studies of eDNA routinely document megafauna DNA in sediments that are thousands of years younger (e.g., ~7 kyr younger for Siberian mammoths) than species' last fossil occurrences. While these datasets are used to propose the continued survival of mammoths and other species well into the Middle Holocene, organisms can contribute DNA to sediments long after their deaths. Because eDNA archives are mixes of undatable DNA from both living and dead individuals, the duration that bones and other biological tissues persist on landscapes is a key aspect of the scale of temporal mixing within an individual eDNA sample. To characterize how the duration of bone persistence changes with environment, we aggregated data on the oldest radiocarbon-dated surface-collected bones from different ecosystems. We included bones that we are reasonably confident persisted without being completely buried ("never buried"), and bones for which exhumation at some point cannot be confidently excluded ("potentially never buried"). We supplemented these data with AMS radiocarbon dated bones from Arctic Alaska and temperate North America. Pairing bone persistence with mean annual temperatures (MAT) from their sample localities, we find a strong link between local temperature and the logged duration of bone persistence (never buried bones, $R^2 = 0.94$, $P < 0.01$; potentially never buried bones, $R^2 = 0.95$, $P < 0.01$). Using mammoths as a test case, we further find that the temporal distribution of mammoth eDNA is within

expectations of the predicted duration that bones in Siberian temperatures can persist on landscapes. Particularly in cold, high-latitude systems where decay rates of bones and other tissues are extremely slow, remains can be ubiquitous on landscape surfaces. Further, even weather-worn specimens can produce viable DNA. Thus, there is a predictable millennial-scale lag between a species' last occurrence (either extirpation or extinction) and the ages of sediments containing the last genetic information of that species. The same environmental characteristics that preserve eDNA also add complexity. Rather than millennial-scale extensions to the survival of megafaunal species, DNA in sediments that significantly postdate last fossil occurrences likely identify temporal mixing in eDNA and highlight how the dead commingle with the living.

Colbert Prize Session

DENTAL TOPOGRAPHY AND ENAMEL THICKNESS ILLUMINATE THE DIETARY ADAPTATIONS OF EOCENE PAROMOMYIDAE (MAMMALIA: PRIMATOMORPHA) FROM ELLESMERE ISLAND, ARCTIC CANADA

Miller, Kristen, Tietjen, Kristen, Beard, K. Christopher

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The Margaret Formation of the Eureka Sound Group in the Canadian Arctic Archipelago samples a unique, warm temperate ecosystem with a polar light regime that dates to the early Eocene epoch ~53 Ma. Although crown clade primates have never been recovered from the Eocene of Arctic Canada, at least two new taxa of paromomyid plesiadapiforms occur there. Because this ecosystem has no modern analogue, this research aims to address the dietary adaptations these paromomyids needed to survive such a unique ecosystem. Dental topographic analysis (DTA) has been used to quantify the three-dimensional surface morphology of teeth to predict general dietary categories (i.e., folivory, frugivory, insectivory, omnivory, and hard-object feeding) in primates. Here we calculate three commonly used dental topography metrics (ariaDNE, RFI, and OPCR) for eight species of paromomyid plesiadapiforms including the two new species from Ellesmere Island using first, second, and third lower molars. The dental topography metrics ariaDNE and RFI along with the natural log of molar length for M_1 and M_2 were used as variables in a discriminant function analysis using a dataset of extant platyrrhines to predict dietary categories for the fossil paromomyids. Of the eight paromomyid taxa included in our analysis only one species, *Phenacolemur pagei*, was consistently recovered as omnivorous. *Paromomys maurus* and *Ignacius fremontensis* were recovered as both omnivorous and hard-object feeding. The remaining five paromomyid taxa (including both Arctic species) were recovered as hard-object feeders. Additionally, we examined enamel thickness on upper incisors to evaluate the hypothesis

that some paromomyids may have been gum feeders. We found that *I. frugivorus* and the only Arctic paromomyid documented by I¹ morphology showed significantly thinner lingual enamel compared to labial enamel, consistent with expectations for exudate feeding or bark gouging. However, these two paromomyid species exhibit vastly different wear patterns on their upper incisors, suggesting important functional differences in the use of these teeth to access dietary resources.

Funding Sources David B. Jones Foundation

Preparators' Poster Session

DUAL OSTEOLOGY GUIDE/WORKFLOWS AS AN ANSWER TO SEVERAL MUSEUM COLLECTION PROBLEMS

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Museum collections have or aspire to have object inventories. Inventories of elements present within each object are less common, and typically imprecise when they exist. Vertebrate specimens are often incomplete; therefore the lack of element inventories strongly affects our field. Collections managers are often unable to provide researchers with a full description of their collections' holdings, which can result in more time and funding allotted for visits than necessary. Museum workers may have issues such as not knowing if, which, or how many elements have gone missing. Inventorying is a time-intensive undertaking. Museums are often short-staffed, and many workers are not guaranteed to have the expertise needed to properly identify every element in all their specimens. To address this, I created the first of many dual osteology guide/workflows for a collection I manage, while updating previous element inventory sheets to more precisely capture anatomy. I used turtles as my first venture since their fused skulls and shells make bone identification easier for beginners. The guide/workflow is sectioned by anatomical region and part type in step with the inventory sheet. Sections contain: images to aid identification; number of elements expected, noting when particular subclades vary from the norm; ways inventorying may differ from other clades; common variances that should be captured in the Notes section of the inventory sheet; and common mistakes to avoid. Numbers are bolded to reinforce them as the information to be recorded. A short introduction includes an authoritative source to reference when species-specific information is needed, as well as a missive to alert the Collections Manager if differing information is found therein so the guide can be updated. A glossary of potentially unfamiliar terms is included. This format should result in more accurate and consistent inventories than have been done in the past. The inventory sheet contains additional helpful fields such as: circling Yes or No for presence of parts the worker was unable to identify; the date and name of the worker doing the inventory; and the

ontological age category of the specimen. Eventually, these physical sheets will be incorporated into the digital database, then made available and searchable online so researchers can more easily estimate the time they need to spend visiting the collection, and museum workers can have a better grasp of their holdings.

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

A NEW PARTIAL SKELETON OF *CHAMPSOSAURUS* CF. *LARAMIENSIS* FROM THE PALEOCENE RAVENSCRAG FORMATION OF SOUTHWESTERN SASKATCHEWAN, CANADA: IMPLICATIONS FOR POST-K-PG EXTINCTION FAUNAL RECOVERY AND PALEOECOLOGY

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The early Paleocene Ravenscrag Formation in southern Saskatchewan overlies the latest Cretaceous (Maastrichtian) Frenchman Formation and is coeval with the Tullock Formation in Montana. The stratigraphy of the Ravenscrag Formation preserves floodplain and low energy swamp environments and is known for rich fossil plant deposits. Vertebrate fossils, including mammals, turtles, crocodiles, and semi-aquatic crocodile-like champsosaurs have also been collected. Herein we present a new 40% complete partial skeleton of the neochoristodere *Champsosaurus* cf. *laramiensis* collected from southwestern Saskatchewan by a joint team of the Royal Saskatchewan Museum and the Canadian Museum of Nature during the summer of 2020. This specimen is significant due to being one of the oldest champsosaurs found above the K-Pg boundary in Saskatchewan and the second-most complete skeleton of *Champsosaurus* cf. *laramiensis* from the province. The fossils come from a thinly laminated terrestrial shale unit within the lower Ravenscrag Formation, likely representing a lacustrine deposit. Additionally, there is a paleopathology on the left hindfoot in the form of a swollen and hollowed-out joint between the third tarsal and the next metatarsal. This paleopathology may have resulted from an infection that formed in an open wound. The low stratigraphic position of this specimen compared to the No. 1 Ferris Coal Seam that preserves the K-Pg boundary seems to imply that champsosaurs recovered quickly following the K-Pg mass extinction event. It is relatively small-bodied compared to the other, large-bodied champsosaur species *Champsosaurus gigas* that occurs within the upper Ravenscrag Formation. Maintaining a relatively small body size across the boundary may have been how champsosaurs and other ecological contemporaries such as crocodiles survived the sudden environmental change that followed the K-Pg mass extinction event.

Technical Session 17: Fish (Saturday, November 5, 2022, 8:00 AM)

THE HEAD, HEART, AND FINS OF A JAWLESS STEM GNATHOSTOME

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A conventional sister group to jawed vertebrates, osteostracans anchor synapomorphies and symplesiomorphies of the clade. This canonical view sets osteostracans in a mosaic of derived gnathostome traits (such as cellular bone) against the background of lamprey-like overall morphology (such as a blind nasohypophyseal canal). Extensive studies of their perichondrally ossified endoskeletons have provided support for this interpretation. However, few CT scans have been undertaken for osteostracan internal anatomy.

Here we present preliminary results from a synchrotron X-ray tomography scan of a new specimen of *Norselaspis* and reveal surprisingly derived gnathostome traits in this osteostracan exemplar. Contrary to earlier interpretations, the vestibular sinus superioris is as tall in *Norselaspis* as those in jawed vertebrates. The pericardial chamber is closed dorsally, which precludes the lamprey-like single midline Cuvierian duct. There is no articular facet in the pectoral cavity, which suggests an entirely fleshy base of the pectoral fin. Our three-dimensional model also enhances key findings from the previous reconstruction, including: configurations of the extraocular muscles and associated motor nerves, exogenous infillings in the labyrinth, and brachial plexus derived of the most anterior spinal projections.

These findings both refine and revise the stem-to-crown continuum of gnathostome characters. *Norselaspis* has derived gnathostome conditions in the inner ear and circulatory system. However, we present evidence that endoskeletal joints emerge with the evolutionary origin of jaws; in this respect, *Norselaspis* remains resolutely plesiomorphic. Interestingly, an apparent lack of the crown-like hypobranchial system in *Norselaspis* implies its independent and divergent evolution in cyclostomes and gnathostomes.

Funding Sources Canadian Museum of Nature; National Science and Engineering Research Council, Canada; the University of Chicago; Museum national d'Histoire naturelle

Technical Session 1: Dinosaurs (Wednesday, November 2, 2022, 8:00 AM)

LO HUECO FOSSIL-SITE (CAMPANIAN-MAASTRICHTIAN, SPAIN), AN IMPORTANT BRICK TO UNDERSTAND THE COMPLEX SYSTEMATICS OF EUROPEAN TITANOSAURS

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The Campanian-Maastrichtian strata of the Ibero-Armorican domain (Southwestern Europe) are rich in titanosaur remains with six described taxa. Most of these taxa are mainly represented by holotypes restricted to a single bone or a small set of associated bones plus referred material from the same multi-taxic bone beds in which the degree of skeletal articulation or association is low and where more than one titanosaur taxon may be represented. As a result, the systematics of the Late Cretaceous Ibero-Armorican titanosaurs is complex due the absence of partially complete titanosaurian specimens with unquestionable association. This scenario dramatically changed with the discovery of the Lo Hueco fossil-site in Cuenca (Spain), a Campanian-Maastrichtian multi-taxic bonebed from the Villalba de la Sierra Formation, which has yielded more than 10,000 fossils of which nearly half correspond to titanosaurian remains, including more than 10 partial skeletons, mostly articulated or with low dispersion. The study of these specimens is key for the understanding of the complex systematics of Late Cretaceous European titanosaurs. Preliminary comparisons suggested the presence of at least two titanosaurian morphotypes based on two types of cranial morphologies, teeth, and appendicular bones. However, higher disparity has been observed in the axial skeleton, especially in the dorsal and caudal vertebrae, and the presence of up to four different taxa in Lo Hueco is not ruled out. In 2016, *Lohuecotitan pandafilandi* was the first established taxon, considered to be a lithostrotian titanosaur. Here, we briefly present seven new and partially complete titanosaurian individuals (HUE-EC-02, HUE-EC-03, HUE-EC-04, HUE-EC-05, HUE-EC-06, HUE-EC-11 and HUE-EC-13), including the most complete lithostrotian of Europe (HUE-EC-02), with an almost complete axial series from the anterior cervical to the middle-posterior caudal vertebrae. These new specimens provide relevant information for formulation and scoring of morphological characters. Our preliminary phylogenetic analyses have recovered *Lohuecotitan*, HUE-EC-02 and *Paludititan* as possible members of Lirainosaurinae together with *Lirainosaurus*, from the upper Campanian-Maastrichtian site of Laño (Treviño County), and *Ampelosaurus* and

Atsinganosaurus, from the Upper Cretaceous of southern France. Our cladistic analyses supports the presence of at least one clade of exclusive forms in the European realm.

Funding Sources Funded by FCT/MCTES (CEECIND/00726/2017), Ministerio de Ciencia e Innovación (PID2019-111488RB-I00), Junta de Comunidades de Castilla-La Mancha (SBPLY/21/180801/000045).

Technical Session 20: Crocodylomorpha (Saturday, November 5, 2022, 1:45 PM)

NEW CROCODYLOMORPH MATERIAL INCLUDING BRACHYCHAMPSA CF. B. SEALEYI AND CF. DENAZINOSUCHUS FROM THE ALLISON MEMBER OF THE MENELEE FORMATION, NEW MEXICO: AN EMERGING PICTURE OF SOUTHERN LARAMIDIAN CROCODYLOMORPH PALEOECOLOGY DURING THE CAMPANIAN

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The Menefee Formation is a Campanian terrestrial deposit in the San Juan Basin of northwestern New Mexico, USA. Reptile fossils previously described from the Allison Member include four genera of dinosaurs and two genera of crocodylomorphs. Here, we add a third crocodylomorph, cf. *Denazinosuchus*, based on three specimens comprising osteoderms and several vertebral centra, alongside fragmentary cranial material representing *Brachychampsia* cf. *B. sealeyi* and a largely complete tooth of *Deinosuchus* sp. to supplement our 2021 report of the first *Deinosuchus* sp. fossils from the Allison Member.

The new *Brachychampsia* material, WSC 16509, includes a fragmentary skull roof, basicranium, and both quadrates. Features on the quadrates support its referral to the genus *Brachychampsia* but the specimen cannot be referred directly to *B. sealeyi*—thus far known exclusively from the Allison Member—due to a lack of overlapping material. Therefore the designation of WSC 16509 as *Brachychampsia* cf. *B. sealeyi* is most appropriate at this time.

First reported cf. *Denazinosuchus* material from the Allison Member includes three specimens (WSC 10610, UMNH VP 28349, WSC 16603) representing three unique size classes, all sharing close morphological similarities with osteoderms referred to *Denazinosuchus* from the younger Fruitland and Kirtland formations, which also crop out in the San Juan Basin of northwestern New Mexico.

Other authors have demonstrated that the Cretaceous is a time of high morphological disparity for crocodylomorphs. Discovery of at least three genera from this group in the

Allison Member contributes to the view that southern Laramidia's eastern coastal territories supported high biodiversity of crocodylomorphs. The presence of identical or very similar crocodylomorphs at key sites across southern Laramidia (Big Bend, San Juan Basin, and Kaiparowits Plateau regions) throughout the Campanian indicates widespread stability and success of this assemblage.

Our ongoing study of crocodylomorph ecology in southern Laramidia includes evaluating each genus (*Brachychampsia*, *Denazinosuchus*, and *Deinosuchus*) on the basis of body length, as this has been shown by other authors to directly correlate with bite force in modern crocodylians, thereby providing valuable insight into their feeding ecology. Tooth morphology is also informative in these discussions; however, our sample of crocodylomorph teeth is limited in number and taxonomically ambiguous, apart from two *Deinosuchus* teeth.

Funding Sources David B. Jones Foundation

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

AN INTRIGUING NEW DIAPSID REPTILE WITH EVIDENCE OF MANDIBULO-DENTAL PATHOLOGY FROM THE EARLY PERMIAN OF OKLAHOMA REVEALED BY NEUTRON TOMOGRAPHY

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The initial stages of diapsid evolution, the clade that includes extant reptiles and the majority of extinct reptilian taxa is surprisingly poorly known. Notwithstanding the hypothesis that varanopids are diapsids rather than synapsids there are only four araeoscelidians and one neodiapsid with both lower and upper temporal fenestrae being present in the Late Carboniferous and early Permian. Here we describe the fragmentary remains of a very unusual new amniote from the famous cave deposits near Richards Spur, Oklahoma that we recognize as a diapsid reptile, readily distinguishable from all other early amniotes by the unique anatomy of its dentition and lower jaw. The teeth have an unusual fluting pattern on the crown, with some teeth posteriorly tilted as well as strongly recurved, while the anterior terminus of the dentary has a ventral protuberance. Overall, the lower jaw is unusually slender with a flattened ventral surface that is formed by the dentary and splenial anteriorly and with a contribution of the angular in the mid-region. The presence of a very slender triradiate jugal revealed through computed tomography confirms the presence of a large lower temporal fenestra, while the medial edge of the maxilla and the anatomy of the palatine confirm the presence of a large suborbital fenestra. Computed tomography reveals that the maxillary innervation of this new taxon is a reptile, not a synapsid. Although there

are no other definitively identifiable elements of the skull roof, the presence of a suborbital fenestra whose borders are preserved on the palatine and maxilla supports the hypothesis that this is a diapsid reptile. Interestingly, the right dentary shows evidence of pathology, a rarely reported occurrence in Paleozoic amniotes, with several teeth having been lost, their sockets filled with bone. This small predator with delicate pleurodont implanted dentition reminiscent of extant snakes provides strong evidence that diapsid reptiles were already diversifying rapidly in the early Permian, but likely were relatively rare members of the terrestrial vertebrate assemblages.

Funding Sources NSERC (Natural Sciences and Engineering Research Council) Discovery Grant to R.R.

Technical Session 1: Dinosaurs (Wednesday, November 2, 2022, 8:00 AM)

RE-EVALUATION OF MAMENCHISAURUS SINOANADORUM (SAUROPODA: MAMENCHISAURIDAE) AND NOVEL INTERPRETATION OF ENIGMATIC JUVENILE SAUROPODS AS MAMENCHISAURIDS

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Although *Mamenchisaurus* was included in the first cladistic analysis of sauropod dinosaurs, it is only recently that the monophyly of the genus and the anatomical diversity of the many named species of Middle–Late Jurassic East Asian eusauropods have been critically evaluated. To that end, we redescribe the holotype and only specimen of *M. sinocanadorum*. Although the original diagnosis of the taxon is no longer adequate, we identify several autapomorphies that support the validity of the species, including an elongate external mandibular fenestra and distinctive pneumatic structures on the ventral surface of the cervical vertebrae. Computed-tomography reveals an extent of vertebral pneumaticity that is comparable to that of the largest sauropods, and updated scaling analyses suggest that *M. sinocanadorum* had a neck over 14 meters long, rivaling previous estimates for other exceptionally long-necked sauropods. We incorporate new anatomical data from comparative study of *M. sinocanadorum* into a phylogenetic character matrix that also includes *Bellusaurus* and *Daanosaurus*, both of which are known only from juvenile

material. Although they were discovered in Late Jurassic strata that have otherwise exclusively yielded early-branching eusauropods, previous phylogenetic hypotheses for *Bellusaurus* and *Daanosaurus* have almost universally favored placement in or a close relationship to Neosauropoda. Our results recover all species of *Mamenchisaurus* as part of a radiation of predominantly Middle–Late Jurassic East Asian eusauropods, but as in previous studies the genus is non-monophyletic, underscoring the need for systematic revision of mamenchisaurid taxonomy. Those of our analyses that score ontogenetically variable characters ambiguously recover both *Bellusaurus* and *Daanosaurus* as juvenile mamenchisaurids, a hypothesis that is supported by several features that are unique to mamenchisaurids or exhibit little homoplasy, including anteriorly bifurcate cervical ribs. Empirical studies have shown that juveniles tend to fall to artifactually basal positions if ontogenetically variable characters are not accounted for. It is therefore striking that previous work has supported a close relationship to Neosauropoda for *Bellusaurus* and *Daanosaurus*. We suggest that the similarities of these juveniles to later-branching eusauropods can be explained by a combination of evolutionary convergence, ontogenetic variation, and unappreciated anatomical diversity within Eusauropoda.

Funding Sources Funding: AJM (NSF DGE-1245908 & OISE 1515288; Jurassic Foundation)

Virtual Posters

THE PLIO-PLEISTOCENE AVIFAUNA OF ROLAND SPRINGS RANCH LOCALITY 1: PRELIMINARY ANALYSIS OF THE WATERBIRD ASSEMBLAGE

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Many extant vertebrate genera of North America first appeared during the late Pliocene and early Pleistocene in association with contemporaneous climatic and geographic changes. The Plio-Pleistocene is, then, a critical interval for documenting the development of the extant vertebrate community. Yet, samples of Plio-Pleistocene birds are scarce, leaving a gap in our understanding of the evolution of the Quaternary avifauna. Roland Springs Ranch Locality 1 (RSR-1), located in Scurry County, Texas, contains a rich assemblage of vertebrate remains preserved in the gleyed clay and cross-bedded sands of a localized alluvial fill deposit. The age of locality is interpreted to be between 3.7 and 2.0 Ma (Blancan Land Mammal Age) based on identified mammalian taxa, including *Nannippus peninsulatus*, *Canis lepophagus*, *Nekrolagus*, and *Aztlanolagus*. Avian remains are abundant and diverse. Initial analysis of the RSR-1 avifauna has focused on the waterbird assemblage. All avian remains occur as isolated, often incomplete, skeletal elements. Identification of those remains is based on extensive comparative analysis of the morphology of modern skeletons. Those morphological

surveys have permitted identification of ibis (*Plegadis* sp.), goose (Anserinae), stiff-tail duck (*Oxyura* sp.), stilt (*Himantopus* sp.), and sandpiper (Scolopacidae) in the RSR-1 sample. The remains appear to represent extinct species, morphologically distinct from the modern species examined. Both the ibis and goose are small relative to extant North American species. The stilt is relatively large, comparable to *H. olsoni* from the Pliocene of Arizona. Recurvirostrids, such as *Himantopus*, are rare in the fossil record globally. The sandpiper, represented by a distal humerus, is closest to *Calidris himantopus* but the specimen cannot be distinguished reliably from forms of *Tringa* or *Phalaropus*. Small scolopacids, *Plegadis*, and *Himantopus*, occur in ephemeral wetlands in the region today as seasonal or occasional migrants. Similar taxa occur in other Blancan local faunas from the Great Plains, including Rexroad Locality 3 and Cita Canyon. Extant populations of migratory waterbirds have declined over the past 50 years. Specimens from RSR-1 help to expand the fossil record of these taxa. That natural history provides a broader context to extant biogeography as well as the recent declines in diversity and abundance.

Technical Session 3: Marine Reptiles (Wednesday, November 2, 2022, 8:00 AM)

CRANIAL VASCULAR PATTERNING IN MOSASAUROIDEA AND SAUROPTERYGIA

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The blood supply to the head not only nourishes the tissues but also is important in brain temperature regulation and thermal physiology. Thus, the evolution of cephalic vasculature is critical for understanding the adaptation of species to extreme environments. This study focuses on the reconstruction of the vascular circulation of the head in two evolutionarily independent secondarily aquatic clades, concentrating on adaptations of the vascular system observed within each clade as a response to an aquatic lifestyle. The cranial arterial and venous circulation in Mosasauroidea and Sauropterygia is inferred from CT scans of fossil specimens and the use of an extant phylogenetic approach involving vascular injections of extant sauropsids. A diverse sampling of extant sauropsids (turtles, squamates, crocodylians, and birds) were injected with a barium-latex solution in their cranial arteries and veins to increase the density of the vessels when CT scanned, allowing the vessels to be accurately reconstructed with the 3D visualization software Amira. From these vascular injections, we were able to identify general patterns of cranial circulation for extinct sauropsids phylogenetically bracketed by disparate extant taxa. Osteological correlates (OCs) for these cranial vascular structures were noted in the extant sauropsids and then extinct mosasauroid and sauropterygian

specimens were surveyed for these OCs. Our results show that both clades had derived venous systems, which could indicate adaptations for their reinvasion of aquatic environments. Both clades show OCs for enhanced venous drainage through the dural venous sinus system, exiting the cranium through the foramen magnum and entering the spinal veins, rather than reliance on just the jugular system. Apomorphic enclosure of some cephalic veins within bones may be an adaptation to limit venous collapse during diving behavior, as structurally, veins are more prone to collapse than arteries. Arterial patterning, however, does not appear to deviate as much from the basal sauropsid condition. Clear OCs for the cerebral carotids are observed within the basisphenoid along with OCs in the parabasisphenoid complex for the common encephalic and sphenopalatine arteries. Although the arterial system is largely plesiomorphic, with some exceptions, the marked deviation in the venous system is similar to the patterning observed in other secondarily aquatic tetrapod clades, such as pinnipeds and cetaceans.

Funding Sources Funding: DJM: Ohio Univ. Heritage Coll. Osteopathic Med., OU Student Enhancement Award (SEA). LMW: NSF IOB-0517257, IOS-1050154, IOS-1456503, & SRC 2021-02973

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

A DESCRIPTIVE AND MORPHOMETRIC SURVEY OF NON-HADROSAURID ORNITHISCHIAN DINOSAUR DENTITIONS FROM THE DINOSAUR PARK FORMATION OF ALBERTA, CANADA

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Although numerous ornithischian dinosaurs are known from the Upper Cretaceous (Campanian) Dinosaur Park Formation of southern Alberta, Canada, interpretations of their biodiversity and palaeoecology are controversial. The body fossil record is taphonomically biased towards the preservation of large-bodied taxa, leaving small-bodied ornithischians underrepresented. While microsite material may be less susceptible to size biases, attaching taxonomic identifications to conservative elements, like teeth, can prove challenging. In this study, we endeavour to elucidate dental variation across the non-hadrosaurid ornithischian clades represented in the DPF by analysing the *in situ* dentition of representative taxa using descriptive and morphometric methods. Hadrosaurids were excluded from this study due to their comparatively unique dental morphologies. The descriptive component of the study revealed differences among taxa based on overall size, crown morphology, point of greatest mesiodistal extent, denticle length, and the presence and morphology of apicobasal ridges. The morphometric

component applied canonical variates analysis (CVA) to eleven linear dental measurements, and the significance of the observed trends was tested using PERMANOVA. Ceratopsids were separated from non-ceratopsids along the first axis, based on the absence of a neck constriction, and individual taxa within both main groupings varied along the second axis according to differences in denticle size and morphology. A confusion matrix correctly classified 94% of the teeth, and PERMANOVA confirmed the significance of the groups identified by the CVA ($p(a) < 0.01$). These results suggest that a combination of detailed qualitative description and quantitative morphometrics may allow for more accurate and precise identification of isolated ornithischian teeth than was previously possible. Consequently, this approach should facilitate a better understanding of ornithischian biodiversity, biogeography, macroevolution, and palaeoecology in the Dinosaur Park Formation and beyond.

Funding Sources NSERC Discovery Grant (RGPIN-2017-06246), NSERC Undergraduate Student Research Award (USRA).

Technical Session 8: Evolutionary Developmental Biology
(Thursday, November 3, 2022, 1:45 PM)

PATTERNS OF AMNIOTE PALATE DIVERSIFICATION AND CONVERGENCE

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Living amniotes display a tremendous disparity in craniofacial form and composition, reflecting over 320 million years of evolutionary divergence. The anatomical specialization and ecological diversification of amniotes makes it relatively trivial to distinguish a modern mammal skull from a bird or a turtle from a crocodylian. However, mammals, crocodylians, and some lizards have independently derived “secondary palates” which divide the nasal and oral passages (to greater or lesser degrees). Further, the fossil record of stem-mammals and stem-crocodylians reveals transitional forms with striking similarities. However, several questions remain unanswered: how convergently similar are “secondary palates”, and are there multiple evolutionary pathways to achieve a “secondary palate”? To address these questions, we performed two- and three-dimensional geometric morphometric analyses of the complete palate, maxilla, and palatine across amniote clades. By sampling all “secondary palate” lineages, the diversity of extant squamates, and major transitions in the fossil record, we identify how key connections among palate elements have changed. These data demonstrate crocodylians and mammals possess remarkably similar palate anatomy, principally due to the presence of extensive palatal shelves on the maxilla and mid-line contact of the palatines. Other reptiles with putative “secondary palates” cluster with other lizards and turtles. Squamates display greater diversity in palate form, likely reflecting greater functional and/or ecological utility of the

palate than in other amniote clades. Extant birds occupy a distinct region due to the enlargement of the premaxilla and strut-like palatines. The inclusion of extinct forms reveals that mammalian and crocodylian palate evolution follow remarkably similar evolutionary trajectories and extant species are significantly more convergent than expected. This is particularly interesting given the gross similarities in palatal shelf outgrowth of both alligators and mice during embryonic development. Based on these findings, we are expanding sampling in order to compare both evolutionary and ontogenetic transformations in palate form in greater detail. Although the drivers of amniote palate diversification are not fully understood, our study clearly demonstrates the need for a more nuanced discussion of palate anatomy and highlights the value of quantitative comparisons across highly divergent clades and anatomical systems.

Funding Sources National Science Foundation (NSF EAR-PF-195288, NSF CAREER-2046868) and Yale University

Virtual Posters

CRANIAL ANATOMY OF *MEGACRICETODON* (RODENTIA, MAMMALIA) AND IMPLICATIONS IN THE PHYLOGENY OF MIOCENE EUROPEAN MUROIDS

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Institut Català de Paleontologia Miquel Crusafont, Cerdanyola
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The family Cricetidae is a clade of rodents belonging to the superfamily Muroidea (Rodentia, Mammalia). Molecular studies have recognized only five subfamilies within the Cricetidae, whereas many paleontological studies consider it a wider group that includes some ancient muroids. The genus *Megacricetodon* was distributed widely from the middle Aragonian to the early Vallesian and is considered a modern cricetid. However, its dental morphology closely resembles the first murids, and some authors considered this genus to be ancestral to the Muridae. Moreover, phylogenetic study of the European Miocene cricetid genera has only focused on dental morphology. The main aim of the present work is to investigate the closest similarities of *Megacricetodon* to recent muroid groups using both internal and external features of the skull.

The studied material is a partial skull of *Megacricetodon ibericus* from els Hostalets de Pierola Superior (MN9; Vallès-Penedès Basin, northeastern Iberian Peninsula). The skull was scanned at CENIEH (Burgos, Spain) using a microCT (model VITomeIX s 240), and subsequently the 3D model was digitally cleaned with 3D Slicer and reconstructed using Meshmixer. This skull was compared with 3D models, microCT data, and photos of 24 different species of all the families of extant muroids obtained from the databases Digimorph, Morphosource, and Sketchfab. Geometric morphometrics in 2D was also used to compare the shape of

the infraorbital foramen using tpsDig2 and Past softwares. Special attention was paid to the zygomatic process, because it is considered an important feature in rodent evolution. In lateral view, the border of the zygomatic plate of *Megacricetodon* is vertical and straight as in some cricetids and calomyscines, and different from other cricetids and nesomyids in which this border is concave, or convex in murids. *Megacricetodon* has a P-shaped infraorbital foramen resembling the condition of some cricetids and calomyscines. Conversely, this foramen is straighter in nesomyids, narrower in murids, and wider and smaller in the rest of muroids. Regarding the internal structures, it is noteworthy that the transversal section of the nasopharyngeal duct of *M. ibericus* is circular, similar to that of some cricetids, whereas in other muroids it is triangular, 8-shaped or even flattened. Based on the cranial features observed in *M. ibericus*, we conclude that this genus is most likely related to the Cricetidae rather than to other muroids.

Funding Sources RMC MSalas MIU-NextGenEU. ÀHL (2019 BP154) Postdoc@MUNI CZ.02.2.69/0.0/0.0/16_027/0008360. PID2020-117289GBI00(MCIN/AEI/10.13039/501100011033)/CERCA/GenCat

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

PHYLOGENY AND BIOGEOGRAPHY OF THE SNAKEHEAD FISHES (TELEOSTEI: ANABANTOMORPHA: CHANNIDAE

Murray, Alison, Holmes, Robert B.

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Snakeheads (family Channidae) are a relatively small group of fishes with 40 extant species divided among two genera (*Parachanna* and *Channa*) found in Asia and Africa. These voracious predators are commercially important both as food fishes and in the aquarium trade and vary from dwarf forms of about 13 cm standard length to larger species that reach well over a meter and are invasive in North America. Fossil channids have been reported from Eocene freshwater deposits of both Africa and Asia. The presence of snakeheads in the two continents in the Eocene leads to biogeographic questions, because these freshwater fishers are intolerant of marine waters and Africa was separated from all other continents for about 100 million years from the Late Cretaceous through to the Miocene. However, a Cretaceous or older age for the group is not supported by the fossil teleost record. In light of this, how snakeheads wound up on both continents in the Eocene is a puzzle. The past biogeographic history of the group can be examined in light of the evolutionary relationships of the fossil and extant members. The relationships of the Eocene fossils with the extant species should indicate whether the group likely arose in Africa and then one lineage moved into Asia or vice versa, or whether the African and Asian forms split prior to the evolution of the

Eocene species and therefore indicate an even older age for the family. Our osteological examination of numerous channid species shows that the primary morphological feature used to separate the two extant genera, a medial lamina on the hyomandibula, which was considered diagnostic of *Channa* species, is in fact not found in all species of this genus. The most recent phylogeny of the channids using morphological features indicates that *Parachanna* and *Channa* are both monophyletic, and are sister groups. This supports the biogeographic hypothesis that channids evolved separately in Asia and Africa; however, fossil channids were not included in that analysis. We here include information from the fossils to shed light on the past biogeography of the channids.

Funding Sources NSERC (Natural Sciences and Engineering Council) of Canada, Discovery Grant 327448 (to AMM)

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

A NEW PALEOGENE FOSSIL AND A NEW DATASET FOR WATERFOWL (AVES: ANSERIFORMES) ELUCIDATE PHYLOGENY AND ECOLOGICAL EVOLUTION

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Despite making up one of the most ecologically diverse and evolutionarily important groups of living birds, the evolutionary relationships and ecological evolution of Anseriformes (waterfowl) remain unresolved. Although Anseriformes have a rich, global Cretaceous and Paleogene fossil record, morphological datasets for this group that include extinct taxa report conflicting relationships for all known extinct taxa. Correct placement of extinct taxa is necessary to better understand ancestral anseriform feeding ecology. Here, we present a new morphological dataset for Anseriformes that includes extant and extinct taxa and describe a new Paleogene anseriform species from the early Eocene Green River Formation of North America. Both provide insight into the phylogenetic relationships and ecological evolution of Anseriformes. The new taxon has a mediolaterally narrow bill which is not known in any previously described anseriform fossil other than Pelagornithidae. The matrix created to assess the placement of this taxon comprises 42 taxa and 718 discrete morphological characters describing skeletal morphology, musculature, syringeal morphology, and behavior. We additionally combine the morphological dataset with published sequences using Bayesian methods, and perform ancestral state reconstruction for ecological characters. Phylogenetic results and ancestral state reconstructions provide insights into waterfowl ecological evolution, including beak and feeding mode evolution.

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Symposium: International Community Connections
(Wednesday, November 2, 2022, 1:45 PM)

COLLECTING IN THE CARIBBEAN: HOW PAST PALEONTOLOGICAL PRACTICES SHAPE PRESENT DAY RESEARCH AND ENGAGEMENT IN TRINIDAD & TOBAGO

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While the Caribbean has been a focus of paleontological research for decades, the specimens that form the basis of this knowledge have largely been exported from Caribbean nations. This non-local accessioning of specimens has not only hindered capacity building and training of local professionals, but also has implications for cultivating appreciation for natural history as national heritage. Further, when carried out over decades, the international dispersion of fossils may lead to data gaps that hinder the accuracy of scientific research itself. Focusing on the twin island nation of Trinidad & Tobago to piece together collections, archival, and digital (e.g., Global Biodiversity Information Facility) data sets, we show how colonial practices in the distant and recent past have shaped our understanding of Pleistocene ecological baselines and extinction dynamics. We review the newly assembled asphaltic fossil record of Trinidad and discuss both previous and planned excavation protocols in light of a community-participatory framework. We share the steps involved in conducting community-engaged paleontological research across international boundaries and provide a positive example of specimen repatriation despite the absence of a local vertebrate paleontology community. We share both research findings to contextualize the Quaternary fossil record of Trinidad & Tobago, but more broadly, share lessons learned for best practices when conducting international paleontological research to ensure reciprocal benefits at all stages of project execution.

Funding Sources We thank National Geographic, the Evolving Earth Foundation, and the Natural History Museum of Los Angeles County for supporting components of this work.

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

SMILODON FATALIS: THE PROWLING PREDATOR PURSUING PREY

Naples, Virginia L., Haji-Sheikh, Misty

Extinct and living mammalian carnivores are generally categorized as being either pursuit or ambush predators. Environmental attributes such as plains versus forest, determine the efficacy of each prey acquisition strategy. Generally, anatomical features of group hunters, or pursuit predators that hunt in open habitats, have gracile bodies, long slender limbs, adaptations maximizing respiratory endurance for long chases, and complex social vocalization patterns, among others. Ambush predators usually are robust, heavily muscled, short-limbed, and can have stubby tails. They capture prey after making short rushes from cover.

During a hunt, mammalian predators seek to remain cryptic. The posterodorsal aspects of their scapulae and the anterodorsal ilial regions are the only body parts that project above the vertebral spinous processes. These highest projections may be visible above any vegetation cover, revealing the predator's presence to potential prey. Forested environments obscure visibility, limit group hunting methods, and require visual and or auditory coordination among group members. These communication methods are problematic in dense vegetation because they would also alert potential prey, enhancing their ability to escape.

The literature shows that the subject of this study, *Smilodon fatalis*, lived in a closed forest environment, and had ambush predator anatomical features. *S. fatalis* was a typical large-bodied, short-limbed, robust animal that has been reconstructed as heavily muscled, with questionable flexibility.

This study proposes that it also had a specialized technique for capturing and killing prey. To date, no characters have been identified that show specific enhancements to *Smilodon's* adaptations for clandestine stalking. *Smilodon* is the only feline with distinctive trapezoidal pectoral and squat pelvic morphological features that improve this sabercat's ability to move stealthily. Truncated scapular and ilial shapes give this cat a lower crouching profile than other felids. When equally flexed, *Smilodon's* forelimbs and hindlimbs allow the shoulder and hip regions to fall below the level of the cat's most dorsal spinous process tips, enhancing *S. fatalis'* ability to flatten its body to facilitate concealment while stalking prey. In conclusion, these morphological limb-girdle features in *Smilodon* provide evidence that shows convincingly how the habits of this animal fit into its environment as a solitary ambush predator.

Romer Prize Session (Thursday, November 3, 2022, 8:00 AM)

DISENTANGLING ONTOGENY FROM PHYLOGENY IN THE ARCHOSAUR CRANIUM

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Ontogenetic development is the process by which phenotypic evolution actually occurs, and as such represents a critical window into the processes underlying major evolutionary transformations. The extreme ontogenetic changes experienced by many non-avian dinosaurs, however, often are difficult to distinguish from phylogenetic differences between species. Determining which specimens represent juveniles of particular taxa is a critical first step for any broader study of dinosaur evolution and paleobiology, but the methods used for this process have never been validated in extant taxa of known identity. I therefore compiled a comprehensive 3D landmark and discrete character dataset spanning the ontogenetic development of *Alligator mississippiensis* and *A. sinensis*, and a single adult *Caiman crocodilus*, to determine whether two quantitative methods – 3D geometric morphometrics and cladistic analysis of ontogeny – succeeded in identifying both the number of species and correctly assigning juveniles to species. Both methods failed to empirically sort specimens into their respective species, but my dataset also reveals two key advances. First, many ontogenetically invariant characters distinguish *Alligator* species from earliest ontogeny. Second, these invariant characters are distributed predictably, and mainly relate to osteological correlates of organ systems that form prior to skeletogenesis. This suggests that their invariance is a consequence of deeply conserved patterns of organismal development, rather than a trait unique to *Alligator*. I leverage these critical observations to develop a novel Bayesian pipeline for species delimitation in the fossil record. This method, termed “Bayesian Identification by Distribution of Ontogenetic Variation” (BiDOV), uses the distribution of ontogenetic and phylogenetic variation in predefined character partitions of an extant training dataset to determine the posterior probability that two fossil specimens belong to the same species. BiDOV outperforms all existing methods, with nearly 90% identification accuracy, and will be improved by compilation of larger, more diverse training datasets. Initial deployment of BiDOV to the dinosaur fossil record reveals several currently accepted ontogenetic series that are likely to be chimeric, including some that have become canonical examples of extreme ontogeny in non-avian dinosaurs, and suggests that our understanding of dinosaur ontogeny may require substantial reevaluation.

Funding Sources Funding information: Research supported by a Richard Gilder Graduate School student fellowship, the Macauley Family endowment, and the Jurassic Foundation.

Education & Outreach Poster Session

CONNECTING RESEARCHERS WITH THEIR COMMUNITIES: IMPLEMENTATION OF AN INNOVATIVE THEMED EXHIBIT AT THE FLORIDA MUSEUM OF NATURAL HISTORY

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Only a small percentage of Florida Museum of Natural History (FLMNH) objects can be displayed and interpreted in our public exhibits. Many more have yet to be described, digitized and made publicly available online, which harbors a wealth of knowledge behind collection doors. To better connect our museum visitors and community with the processes of scientific research on such hidden objects, we have developed an innovative, themed space entitled ‘Science Up Close.’

The first theme in this rotational series is ‘Fantastic Fossils’. Combined, the FLMNH paleobotany and palynology, invertebrate, and vertebrate paleontology collections have cataloged nearly 4 million specimens. Many more have yet to be cataloged. Working from a community opinion survey, FLMNH exhibit developers and paleontologists, brainstormed a list of some of the most interesting and scientifically valuable fossils housed within the collections. Our thematic goal was for visitors to leave with a better understanding of the scientific process behind paleontology, emphasizing how fossils reveal secrets about ancient life and what those findings might mean for the future of the planet.

These concepts are delivered through 9 months of flexible researcher-led workshops and full-time visitor engagement with the paleontology labs operating daily on display, in the exhibit. For a broader perspective on paleontology, live streaming interactive events are regularly scheduled from offsite collections and fossil excavation sites (e.g., Florida, Wyoming).

To aid this dynamic exhibit content, fossils and associated stories are delivered through 360-degree interactive exploration tours of an excavation site and paleontology collections paired with virtual reality headsets and a touchscreen TV. Also included is a microscope work area for researcher-led hands-on activities, a theater showcasing interviews from a diversity of fossil enthusiasts, interactive touch screens, a light table for artistic exploration, and a library activity area. This exhibit allows museum visitors and community members to experience what goes on behind the scenes and understand the vastness of the FLMNH collections. It also provides any number of our 700 plus community volunteers an avenue to showcase their experiences and expertise, demonstrating that anyone can be a paleontologist. ‘Science up Close’ brings objects and their stories to the surface for public engagement with ongoing scientific research.

Technical Session 18: Birds (Saturday, November 5, 2022, 1:45 PM)

THREE-DIMENSIONAL ENANTIORNITHINE BRAINCASE CLARIFIES THE ORIGIN OF THE CROWN BIRD ENDOCRANIUM

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Crown birds (Neornithes) exhibit highly modified endocranial morphology, including the anatomy of the brain and inner ear. However, a dearth of three-dimensional fossils from Mesozoic stem-avians has limited our knowledge of the origin of the distinctive neornithine endocranium. Traits like an expanded brain, a ventrally positioned connection between brain and spinal column, and a modified vestibular system (balance organ) of the inner ear have been regarded as crown-bird synapomorphies. Here, we demonstrate the existence of all these traits in an undistorted stem-bird (Enantiornithes) braincase from an Upper Cretaceous (~80 MYA) avian bonebed in south-eastern Brazil (William's Quarry, Presidente Prudente, Sao Paulo State). Our discovery illustrates how these 'advanced' endocranial traits either originated prior to the split between Enantiornithes and the more crownward portion of the avian tree, or convergently arose in both lineages. Surprisingly, the braincase also retains a remarkably plesiomorphic cranial base and posterior palate region. Altogether, our results support the interpretation that avian endocranial morphology is dictated by a complex trade-off between spatial constraints and ecological factors.

Funding Sources DJF and GN acknowledge support from UKRI Future Leaders Fellowship MR/S032177/1.

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

PROBOSCIDEANS REMAINS THE FROM CHINJI FORMATION (MIDDLE MIOCENE) OUTCROPS OF CHABBAR SYEDAN, PUNJAB, PAKISTAN

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The Siwalik Group or Siwaliks is known for the mammalian remain for about two hundred years. Various mammalian taxa have been recorded from the Siwaliks, including Proboscidea. Here, new proboscidean material from the middle Miocene of Chabbar Syedan is described and discussed. The specimens comprise a dentary, tusks, symphyseal fragments, and isolated teeth, that belong to four proboscidean species within three genera: *Deinotherium pentapotamiae*, *Deinotherium* sp.,

Protanancus chinjiensis, and *Gomphotherium browni*. Significance of this material lies in the first description of a *Protanancus chinjiensis* dp2, and a dentary after a long time, and first description of a tusk fragment of a fully adult *Gomphotherium browni* individual. We also provide a brief paleobiogeographic sketch of these taxa within context of the Siwaliks.

Technical Session 19: Marine Mammals (Saturday, November 5, 2022, 1:45 PM)

TAXONOMIC AND PHYLOGENETIC STUDY OF THE LATE OLIGOCENE HETERODONT ODONTOCETE *EOSQUALODON LANGEWIESCHEI* PROVIDES CLUES ABOUT THE EMERGENCE OF MODERN TOOTHED WHALES

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The Squalodontidae is an enigmatic family of early odontocetes, or toothed whales, with a nebulous taxonomy and phylogenetic position. The family has long been considered a "wastebasket taxon" containing many fragmentary remains of heterodont cetaceans. Presently, the genera *Eosqualodon*, *Squalodon*, and putatively *Phoberodon*, are assigned to this family. The Squalodontidae possess a mixture of ancestral and derived traits. Their skulls exhibit more advanced degrees of telescoping than stem odontocetes, however, they still possess a differentiated dentition along their tooth row. Given this, the Squalodontidae would seem to be transitional forms as highly derived stem odontocetes. However, various workers have proposed that the Squalodontidae belongs within the crown Odontoceti as the basal-most member of the Platanistoidea. This clade, now monogeneric and restricted to the south Asian river dolphin (*Platanista*), was once extremely diverse. This second phylogenetic hypothesis has profound implications for the evolution of dental simplification and homodonty within the Odontoceti. Complicating matters is the fact that basic taxonomy for this family has languished for decades. To better resolve the evolutionary position of the Squalodontidae, we examine the Chattian (26 Ma) fossil whale *Eosqualodon langewieschei* from the Doberg Formation of northwest Germany. *E. langewieschei* is represented by a complete skull and mandible, with the left tympanic bulla and periotic prepped out. This species is the type for the genus *Eosqualodon* and remains the most poorly studied within the family; it has received neither sufficient diagnosis nor description and has never been placed within a phylogenetic analysis. We demonstrate the taxonomic validity of the genus *Eosqualodon* through morphological comparison with other contemporaneous odontocetes. Furthermore, we coded *E. langewieschei* and *Squalodon bariensis* into a comprehensive phylogenetic analysis of Odontoceti. Using a molecular backbone under both equal and implied weights, we recovered a sister relationship between *E. langewieschei* and *S.*

bariensis, supporting *Eosqualodon*'s current assignment to the Squalodontidae. Our analysis also supports the hypothesis that the Squalodontidae are derived stem odontocetes.

Technical Session 2: Paleoecology (Wednesday, November 2, 2022, 8:00 AM)

A RARE MICROVERTEBRATE ASSEMBLAGE FROM THE TRIASSIC MANDA BEDS OF TANZANIA FILLS IN THE RECORD OF VERTEBRATE RECOVERY AFTER THE END-PERMIAN EXTINCTION

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Terrestrial vertebrate communities were completely reorganized after the end-Permian extinction (~252 Ma). Macrovertebrates have been used to chronicle the timing of recovery and reorganization of these communities. However, the diversification of smaller-bodied vertebrates is poorly recorded and hampered by the few localities that are taphonomically appropriate to sample animals of this size. Here we report an exceptionally rich microvertebrate assemblage from the highly fossiliferous upper Lifua Member of the Manda Beds (Middle–?lower Upper Triassic) of Tanzania. We surface collected the productive horizon and bulk sampled sediment for screen washing (multiple rounds of soaking in water and a final bath in 5% acetic acid). Specimens recovered from sorting are uniformly disarticulated and generally well preserved (neither weathered nor abraided), few fossils measure more than 5 cm in any dimension, and the abundance of fossils is very high. Among the identified paleocommunity members, immature specimens of a silesaurid (likely *Asilisaurus kongwe*) dominate the assemblage: thousands of bones are preserved, and at least 30 astragali of various sizes were recovered. In addition, the following taxa are represented (*= new records for the Manda Beds): gastropods*, bivalves, chondrichthyans (hybodont* and xenacanth* teeth), actinopterygian scales, jaw fragments*, lungfish tooth plates*, temnospondyl vertebrae and teeth, cynodonts (traversodontid and probainognathian teeth), small reptiles represented by jaws fragments and vertebrae (possibly colognathids* and lepidosauromorphs*), and a variety reptiles represented by serrated teeth (likely archosauriforms). Many coprolites are present, some with embedded scales. The larger members of the assemblage reflect the macrovertebrates found in the Lifua Member, whereas the smaller vertebrates only are found through screenwashing. Locally, the most similar microvertebrate assemblage is from the Middle Triassic Ntaware Formation of Zambia, suggesting small vertebrate faunas were broadly comparable at a regional scale, but few other comparative microvertebrate assemblages are known

from coeval rocks across Pangea, limiting detailed comparisons. This Manda Beds microvertebrate assemblage serves as an important comparative data point for the Triassic diversification of small-bodied clades, and underscores the importance of employing collecting techniques that sample this portion of the fauna.

Funding Sources National Geographic Society Research and Exploration grant (9606-14, S.J.N.), National Science Foundation EAR-1337569 (C.A.S.) and EAR-1337291 (K.D.A., S.J.N.)

Technical Session 7: Paleogene Mammals & Primates & Carnivora (Thursday, November 3, 2022, 1:45 PM)

CEMENTOCHRONOLOGY REVEALS THE EVOLUTION OF LIFE HISTORY AMONGST THE EARLIEST MAMMALS

Newham, Elis¹, Gill, Pamela G.², Brewer, Philippa³, Schultz, Julia⁴, Jaeger, Kai⁴, Corfe, Ian J.⁵, Martin, Thomas⁴

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The physiology of Mesozoic mammals is crucial for understanding the evolution of mammalian endothermy. However, it is only with the emergence of new techniques that we have been able to apply common metrics (lifespan, growth-rate, age-at-sexual-maturity) for estimating their physiological status. Our paper using synchrotron X-ray imaging to count annual growth increments in fossilized cementum, the mineralized tissue anchoring mammal teeth to the jaw, in the early mammaliaforms *Morganucodon* and *Kuehneotherium* has offered a new tool for understanding their physiologies by estimating their maximum lifespan and basal-metabolic-rate (BMR). Comparison of these values to those of extant mammals suggests that early mammaliaforms had yet to achieve mammalian endothermy. Here, we apply further techniques to study cementum, validated on extant mammals, to explore physiology in a broader sample of non-mammalian mammaliaforms and early crown mammals. The extant mammal physiologically determinate growth strategy is reflected in the structure of cementum, with rapid juvenile growth truncated at the advent of sexual maturity, marked by a significant decrease in increment width and increase in increment contrast. The relative growth-rate of cementum is also significantly and sub-allometrically correlated with body-mass in extant taxa, permitting generation of mass-specific growth-rates to directly compare between taxa. The application of these techniques in Mesozoic fossils from the Kirtlington (Bathonian, UK) and Guimarota (Kimmeridgian,

Portugal) faunas has allowed us to quantitatively study their growth-rates and patterns for the first time, and compare these metrics across time, geography, and phylogeny. While both mammaliaforms and crown-mammals retained significantly longer lifespans than similar sized extant terrestrial mammals, we find that mammaliaforms retained indeterminate growth patterns and low growth-rates through life compared to cladotherian-grade mammals. Cladotherians show the beginnings of a determinate growth strategy, with a truncation in growth and change in structure similar to extant mammals. However, the comparatively small difference between juvenile and adult growth-rates and delayed point of truncation suggests a physiological disparity between extant and early crown mammals. We conclude that cementochronological evidence supports a delayed development of mammalian endothermy in Mesozoic mammals, originating during the Mid-Late Jurassic.

Funding Sources NERC UK; EPSRC UK; Alexander Von Humboldt Institute Germany.

Technical Session 20: Crocodylomorpha (Saturday, November 5, 2022, 1:45 PM)

A NEW NOTOSUCHIAN CROCODYLIFORM PHYLOGENY: THE IMPORTANCE OF INCREASED CHARACTER AND TAXON SAMPLING VIA THE USE OF CONTINUOUS CHARACTERS AND STANDARDIZED CHARACTER CONSTRUCTION

Nicholl, Cecily¹, Marwood, Ella¹, Burke, Paul¹, Mahboubi, Mohammed², Pol, Diego³, Mannion, Philip D.¹

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Notable for their high ecomorphological diversity, notosuchians are an extinct, speciose group of terrestrial crocodyliforms with a preference for semi-arid environments. Although the group has high apparent diversity in continental deposits of the middle–Late Cretaceous of Gondwana, discoveries of numerous fossil remains in the last few decades have increased the temporal and geographic range of the clade, with several possible species described from Europe and China. Since the erection of Notosuchia, there have been ongoing disputes regarding the inter-relationships and composition of its members, especially in terms of the placement of sebecid sebecosuchians, the only putative notosuchian taxa to survive the Cretaceous/Paleogene mass extinction, 66 Ma. In this work, phylogenetic inconsistencies are confronted through improved taxon and character sampling, with emphasis placed on the increased inclusion of continuous data and sebecosuchian taxa, particularly several fragmentary specimens excluded from most recent systematic studies, despite their biogeographical significance. These include *Doratodon* (*D. carcharidens* and *D. ibericus*) from the latest Cretaceous of Europe, and *Eremosuchus elkoholicus*

from the early Eocene of north Africa. A new character-taxon dataset is produced via standardized approaches to character construction and first-hand study of the majority of taxa. It comprises the largest notosuchian-relevant character-taxon matrix yet to be compiled, consisting of 632 characters (157 of which are continuous) scored for 115 crocodyliform taxa, of which 88 are notosuchians. This represents an increase in the total character count of ~42% and an increase in the number of notosuchians by ~46% compared to the largest existing dataset. Phylogenetic analyses are run under maximum parsimony using multiple character weighting schemes, including equal and extended implied weighting. Sebecosuchia is confirmed as a derived notosuchian clade, comprising a monophyletic Baurusuchidae and Sebecidae. *Eremosuchus elkoholicus*, following a detailed redescription, is recovered as an early diverging sebecosuchian and the sister taxon to *Lorosuchus nodosus*, from the Paleocene of Argentina. A critical appraisal of phylogenetic characters, as well as the incorporation of previously neglected anatomical and taxonomic data, provides a nuanced view of notosuchian evolution and biogeographic history, and improves our understanding of the clade's dispersal and radiation.

Funding Sources Royal Society research grant (RGFR1\180020)

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

TESTING THE SKULL PERFORMANCE OF THE MEIOLANIID *NIOLAMIA ARGENTINA* (TESTUDINATA) USING FINITE ELEMENT ANALYSIS

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Meiolaniids were giant, terrestrial turtles characterized by the presence of frills and horns in the skull and tails covered by rings ending in a tail club. These bizarre turtles lived from the Eocene to the Holocene of Australia and Southwestern Pacific Islands and in the Eocene of Patagonia, Argentina, where only two named species of meiolaniids are known. In this contribution, we focused on one of the Argentinean species, *Niolamia argentina*, known for an almost complete skull, lower jaw, tail ring, both scapulae, and carapace fragments. In the present study, we performed a finite element analysis (FEA) on the skull of *Niolamia argentina* to explore (1) the cranial performance simulating defensive/aggressive movements, and (2) the possible function of frills and horns in the skull. FEA calculates the stress and deformation exhibited in a digitally generated structure, in response to the loads applied to it. The virtual model of the skull of *N. argentina* was reconstructed based on CT scans performed on the

neotype (MLP 26-40), and the analysis was performed using published data on homogeneous crocodile bone properties (Young's modulus: 20.49 GPa; Poisson ratio: 0.4; Bone density: 1.77 g/mL). We tested five different scenarios where a strong load was applied: (1) snout hitting (as observed in extant tortoises), (2) hitting with the forehead (as observed in extant tortoises), (3) struggling with the notch between the frill and the horn, (4) stabbing with lateral horns and (5) caudal torsion of the frills. The less stressful scenarios were (1), (2), and (3), whereas the most stressful were (4) and (5), especially the last one. Although aggressive behavior is quite common among male extant tortoises, based on these results, we can hypothesize that the horns and frills of *N. argentina* are more suitable for sexual display than for combat, because the observed results imply that if two aggressive males engage in combat, hitting each other with the caudal frills or the lateral horns may represent a dangerous scenario. Future studies in other meiolaniid species will provide more information about the skull performance in this bizarre group of turtles.

Funding Sources PICT 2017-1319 (FD); PUE 2016-CONICET-CICTERRA; PICT 2018-01848 Préstamo BID (JS).

Education & Outreach Poster Session

TRENDING ON TIKTOK - THE POTENTIAL FOR PALEONTOLOGY EDUCATION AND OUTREACH ON THE WORLD'S FASTEST GROWING SOCIAL MEDIA PLATFORM

Northover, Joanna M.

None, Ottawa, Ontario, Canada

As one of the fastest growing social media applications of all time, TikTok has great potential as a medium for paleontology outreach and education. The nature of how content is distributed on the platform means paleontology content can reach new and underserved audiences - inspiring and sparking their interest and curiosity in the subject. To better understand the paleontology community on TikTok, online surveys were created for content creators and content consumers. Responses were solicited by posting TikTok videos and stories, directly contacting paleontology creators, and sharing the survey links on other social media platforms. According to the responses collected, paleontology TikTok creators have over 2 million followers combined, and the majority of them produce new content multiple times per week. As a whole, the paleontology community on TikTok regularly creates content that receives over 10 thousand views, and they produce videos that reach over 1 million views 3-4 times per month. The majority of the creators surveyed represent personal accounts - single individuals sharing information, and their passion, about paleontology. Paleontology creators are followed by users from a variety of age groups and educational backgrounds, and over 75% of them report seeing paleontology content at least "sometimes" while using the application. Over 73% of content consumers surveyed reported learning something

“often” or “always” from paleontology themed TikTok content they watch. Increasing creator diversity, collaborations between creators, collaborations with institutions, and real time interactions with users through the TikTok LIVE feature are ways to increase the reach, and engagement with, paleontology education on the platform.

Technical Session 15: Theropods (Saturday, November 5, 2022, 8:00 AM)

NEW BODY RATIOS PROVIDE ADDITIONAL SUPPORT FOR *DROMICEIOMIMUS* AS A VALID ORNITHOMIMID TAXON

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Validity of the ornithomimid taxon *Dromiceiomimus* has been debated for decades having first been diagnosed by body ratios (e.g., antilium, tibia, metatarsus, and pedal digit III longer relative to femur compared to *Ornithomimus* and *Struthiomimus*). Since the early 2000s the genus has been treated as a synonym of *Ornithomimus edmontonicus*, due to similarities in skull morphology; however, these similarities could instead reflect a sister taxon relationship or indicate *Dromiceiomimus brevitertius* is a species of *Ornithomimus*. Renewed discussion surrounding the validity of *Dromiceiomimus* followed the recent assignment of the specimen UALVP 16182 to the taxon *D. brevitertius* based primarily on body ratios. We explored the utility of body ratios for distinguishing existing ornithomimid taxa. Measurements from specimens of the genera *Dromiceiomimus*, *Ornithomimus*, *Struthiomimus*, *Rativates*, *Gallimimus*, and *Sinornithomimus* were utilized. These linear measurements were divided into data sets by body region and missing values were imputed using the R package ‘missMDA’. Multivariate ratio analysis (MRA) was applied to the ornithomimid measurements by combining principal component analysis (PCA) and linear discriminant analysis (LDA). Overall, the PCAs provide support for several differences in shape among genera. The LDA ratio extractor identified two ratios from the manual unguals: unguual length/ungual proximal height, and unguual proximal width/ungual proximal height that distinguish *Dromiceiomimus* from *Ornithomimus* and *Struthiomimus*, respectively. Ratios from the limb bones, pelvis, and pes distinguish *Dromiceiomimus* from *Ornithomimus*, *Struthiomimus*, *Rativates*, *Gallimimus*, and *Sinornithomimus* when compared in a pairwise fashion. Three key ratios emerge from the multiple pairwise comparisons: (1) femur length/fibula length, (2) femur length/tibia length, and (3) pubis length/metatarsal III length. There has been some question regarding the utility of limb ratios in the diagnosis of ornithomimid taxa, namely the lengths of the femur and tibia to diagnose *Dromiceiomimus*. This analysis not only validated

the use of historical ratios to delineate ornithomimid genera, but also revealed a new series of ratios that provide additional support to recognize *Dromiceiomimus* as a distinct ornithomimid taxon.

Funding Sources NSERC PGS-D to REN and NSERC Discovery Grant to JMT.

Technical Session 9: Mammals (Friday, November 4, 2022, 8:00 AM)

CLIMATE CHANGE PRIMED SOUTHERN CALIFORNIA FOR HUMAN-IGNITED ECOSYSTEM COLLAPSE 13,200 YEARS AGO: A HIGH-RESOLUTION RADIOCARBON RECORD OF MEGAFAUNAL MASS EXTINCTION AT RANCHO LA BREA

O'Keefe, Frank R.¹, Dunn, Regan², Weitzel, Elic³, Waters, Michael⁴, Binder, Wendy J.⁵, Southon, John R.⁶, Cohen, Joshua⁷, Meachen, Julie A.⁸, DeSantis, Larisa R.⁹, Lindsey, Emily L.²

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The causes of the Pleistocene megafaunal extinctions have been difficult to establish, largely due to poor chronological resolution in a fossil record that is also sparsely sampled. To address this lack of resolution, we leveraged the many fossils available from the Rancho La Brea (RLB) *lagerstätte* by obtaining 153 new radiocarbon dates on common mammals found in the deposits. These dates span a chronological window of 16–10 thousand calendar years before present (ka), and sampled the six most common large mammals at RLB (*Smilodon fatalis*, *Aenocyon dirus*, *Canis latrans*, *Bison antiquus*, *Equus occidentalis*, and *Camelops hesternus*). For *Smilodon*, *Equus*, *Aenocyon*, and *Bison antiquus*, the dates reported here are the youngest reliable occurrences for North America. Modeling of extinction timing using several methods establishes that all taxa except coyotes disappear at RLB at a median age of 13.02 ka, nearly 100 years before the onset of the Younger Dryas (YD) and at least 1,000 years before the continental extinction of North American megafauna. The disappearance of all taxa is synchronous save that of camels,

who disappear slightly earlier. Coyote deposition continues after the megafaunal extinction, demonstrating that the tar pits continued to trap mammals after the local extinction. Comparisons with high-resolution climatic and floral datasets reveal that the regional extinction event coincided with a radical ecological state shift in southern California. This punctuated ecological transition was characterized by fundamental floral reorganization accompanied by unprecedented fire activity, and was preceded by more gradual aridification and vegetation changes attributable to deglacial warming during the Bølling-Allerød. Variance autoregressive time series modeling strongly implicates humans as the primary cause of the state shift and resulting extinctions; the change in regime was triggered by increasing direct and indirect human impacts in an ecosystem increasingly prone to catastrophic fires. The extinction at RLB is abrupt, predates the Younger Dryas, and was concurrent with a catastrophic, anthropogenic fire event that led to fundamental restructuring of the floral and faunal communities.

Funding Sources This project was funded by the National Science Foundation grants NSF EAR 1758117; 1757545; 1758116; 1758108; 1757236; and 1758110.

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

A NEW VERTEBRATE MICROFOSSIL ASSEMBLAGE FROM THE UPPER CRETACEOUS BAYNSHIRE FORMATION, GOBI DESERT, MONGOLIA

Okoshi, Tsukasa¹, Saito, Hokuto¹, Kubo, Futo¹, Takahashi, Akio¹, Saneyoshi, Mototaka¹, Chiba, Kentaro¹, Buuvei, Mainbayar², Tsogtobaatar, Khishigiav²

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The fossil record of the Upper Cretaceous strata in Mongolia comprises an incredible array of small to large vertebrate fossils, representing a diverse ecosystem in this unique inland environment. Most of the exquisite vertebrate fossils come from the Djadokhta, Barun Goyot, and Nemegt formations, but those of the underlying Baynshire Formation are less abundant, especially with regards to small vertebrates. In this study, we report a new vertebrate microfossil assemblage that our group recently discovered from the Baynshire Formation to fill the significant gap in the fossil record of small vertebrates from this formation. The new assemblage was discovered at Bayn Shire, the type locality of the Baynshire Formation in the Gobi Desert, Mongolia. It was recovered from the lower fossiliferous beds of the outcrop, preserved in point bar deposits of a meandering river system. The majority of the assemblage is composed of dinosaur teeth (including tyrannosauroid, dromaeosaurine, sauropod, ankylosaurid and hadrosauroid) and indeterminate dinosaur bones and eggshells as well as crocodylian, turtle (including trionychnid and adocid),

and fish elements. Notably, this assemblage includes the remains of taxonomic groups not previously discovered from this formation: actinopterygian sinamiid dentaries, a squamate humerus, and a eutherian zhelestid dentary. The new taxonomic groups discovered from the assemblage contribute to a better understanding of the fauna in the Baynshire Formation and provide paleobiogeographic and evolutionary insights into these groups. Recent U/Pb dating on caliches in the Baynshire Formation suggests that this fossil assemblage represents the fauna during the Cretaceous Terrestrial Revolution (ca. 95 mya). It is hypothesized that the diversification of angiosperms drastically modified terrestrial ecosystems during this event, but little is known about how this event proceeded, partially due to the global scarcity of fossils during this time period. Further excavation and investigation of this assemblage will be an intriguing opportunity to document faunal changes during this important macroevolutionary event.

Funding Sources Grants-in-Aid for Scientific Research by JSPS; Private University Research Branding Project and Bilateral Program (JPJSBP120219941) by MEXT, Japan.

Romer Prize Session (Thursday, November 3, 2022, 8:00 AM)

ALLOMETRY OF BONY SOUND RECEPTION STRUCTURES AND EVIDENCE FOR A MANDIBULAR EAR IN NON-MAMMALIAN SYNAPSIDS

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The evolution of the mammalian middle ear from the quadrate, stapes, and postdentary bones of non-mammalian synapsids offers valuable information about major evolutionary transitions. However, our understanding of the selective pressures that drove the evolution of this trait is limited by a poor understanding of hearing capabilities in non-mammalian synapsids. This work investigates the hypothesis that non-mammalian therapsids used their reflected lamina, a plate of bone on the mandible, for sound reception. I test this hypothesis by characterizing the relationship between allometry and sound reception use in a bony structure, as the vibration of a structure depends largely on its size. Allometry is first analyzed in the pterygoid of chameleons, which is used for hearing in some species and represents a functional analog to the hypothesized therapsid mandibular ear. The area of the pterygoid is regressed against basal skull length for chameleon species with and without a pterygoid ear. Results indicate that chameleons with a pterygoid ear converge on similar allometric coefficients, while other species have highly variable coefficients, suggesting stabilizing selection for allometry in bony sound receivers. Ornstein-Uhlenbeck Hansen models of evolution also support an increase in stabilizing selection in the allometric coefficient of the chameleon pterygoid in lineages that use it for hearing. The area of the synapsid reflected lamina is regressed against

mandibular length to investigate how the allometry of this structure evolved throughout Synapsida. Variance around the allometric curve is substantially reduced in therocephalians and non-bidentalian anomodonts compared to other non-mammalian synapsids, suggesting a restricted allometric coefficient, similar to that seen in chameleons with a pterygoid ear. Ornstein-Uhlenbeck Hansen models corroborate this pattern, suggesting an increase in stabilizing selection in the allometry of the reflected lamina in therocephalians and non-bidentalian anomodonts. These results represent the first empirical evidence for a functioning mandibular ear in non-mammalian synapsids and suggest that selective pressures for hearing ability were present in this lineage long before the evolution of the mammalian middle ear.

Funding Sources SVP Cohen Prize, AAUW American Fellowship, U. Washington WRF-Hall Fellowship and Snyder Award, Paleontological Society Feldmann Grant, NSF (ANT-1341304 and EAR 1337569)

Technical Session 10: Soft Tissues & Taphonomy (Friday, November 4, 2022, 8:00 AM)

COMPARING THE ACCURACY AND PRECISION OF XRF AND ICP-MS ANALYSES OF FOSSIL BONE GEOCHEMISTRY

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Fossil bone geochemistry can be used to study taphonomic processes like diagenesis. X-ray fluorescence (XRF) and inductively coupled plasma mass spectrometry (ICP-MS) analyses can be used to study bone geochemistry. ICP-MS is assumed more accurate than XRF. It was hypothesized that accuracy and precision varies based upon concentration of the element being considered and the depositional environment of the bones analyzed. To test such hypotheses, cortical bone from seventeen fossil vertebrae, including nine hadrosaur vertebrae from the Hell Creek Formation and eight mosasaur vertebrae from the Pierre Shale Formation, were examined non-destructively and destructively. Both formations used represent varied depositional environments. Thirteen elements were analyzed, including aluminum, calcium, potassium, magnesium, manganese, and strontium. Bones from the Pierre Shale had significantly higher concentrations of aluminum compared to the Hell Creek and significantly lower concentrations of manganese ($p < 0.05$). This was supported by XRF and ICP-MS results. A significant difference between non-destructive and destructive XRF data and destructive XRF and ICP-MS data was found for most elements, indicating a difference in the accuracy of these methods for most elements. Statistical tests supported non-destructive and destructive XRF finding similar concentrations of magnesium ($p = 0.56$) and

manganese ($p = 0.40$). Calcium ($p = 0.14$), manganese ($p = 0.25$), and strontium ($p = 0.12$) concentrations between XRF and ICP-MS results were insignificantly varied. Accuracy was not found to differ based on formation, revealing it did not vary with depositional environment. Based on relative standard deviation (RSD) values, most elements, except potassium and manganese, were found having significant differences ($p < 0.05$) between non-destructive and destructive XRF, and between destructive XRF and ICP-MS. Aluminum was insignificantly varied for destructive XRF vs ICP-MS ($p = 0.13$), yet it was for non-destructive vs destructive XRF ($p = 4.11 \times 10^{-5}$). One element, aluminum, differed between the Pierre Shale and Hell Creek formations. It was found to be detected less accurately when using XRF, but both XRF and ICP-MS results supported higher aluminum concentrations in the Pierre Shale. Despite the lower of accuracy of XRF for aluminum, the XRF results still supported interpretations consistent with ICP-MS results, which has implications for using XRF to study fossil bone geochemistry.

Technical Session 9: Mammals (Friday, November 4, 2022, 8:00 AM)

STATISTICAL ANALYSIS OF DENTAL VARIATION IN THE EOCENE-MIOCENE FELIFORM PALAEOGALE

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The basal feliform *Palaeogale* is well represented in the Eurasian and North American fossil records of the Eocene through Miocene but remains enigmatic in many ways. This is due in part to uncertainty surrounding its phylogenetic position and taxonomy. Many species have been distinguished from others based purely on body size despite showing differences in size comparable to those seen between males and females within extant, sexually dimorphic carnivorous species. Lower dentition has long been central to *Palaeogale* systematics, and we gathered linear measurements of lower cheek teeth from museum collections and published literature to test whether the relative sizes and overall shape of these teeth were a more reliable tool for distinguishing taxa. Our comparison of three relatively well-sampled species – *Palaeogale minuta*, *Palaeogale sectoria*, and *Palaeogale dorothiae* – showed that first lower molar length (a proxy for body size) differed significantly between taxa. However, it showed no significant differences in relative size or shape for any lower premolar or molar between taxa. That *Palaeogale* dental morphology is highly variable – possibly even within species – is underscored by a principal components analysis that reveals overlapping morphospaces for the three species. This high degree of variability in *Palaeogale* dentition indicates the need for a rigorous geometric morphometric analysis of finer-scale dental morphology within the genus and for inclusion of traits from the upper dentition, cranium, and

postcrania, all of which have historically been underutilized in the study of this paleobiologically fascinating genus.

Funding Sources Funds supporting this research were provided by Gonzaga University and the M.J. Murdock Charitable Trust.

Technical Session 4: Paleobiogeography (Wednesday, November 2, 2022, 1:45 PM)

BERGMANN'S RULE WAS ABSENT IN MESOZOIC DINOSAURS AND MAMMALS

Organ, Chris¹, Keller, Lauren², Gardner, Jacob D.¹

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Global temperature gradients govern the distribution of species and the structure of ecosystems. Climatic variation can also induce varying selection pressures as animals disperse. For example, Bergmann's rule describes the well-known increase in body size among related species at higher latitudes. Yet, most 'rules' describing ecologic-geographic relationships are premised on extant species. The fossil record provides repeated natural experiments in different climatic conditions to uniquely test these types of hypotheses. Given their enormous size range and global distribution, dinosaurs are well suited to evaluate Bergmann's rule. Together with Mesozoic mammals, we provide two independent tests for Bergmann's rule from an age when the climate was consistently warmer. Consequently, we hypothesized that dinosaur and mammal body size was uncorrelated with latitude. We used phylogenetic models and reconstructed palaeocoordinates to test this relationship while accounting for gaps and bias in the fossil record. We find no evidence that body size covaries with latitude. Also, despite overwintering, dinosaurs from the Cretaceous Arctic Circle are no larger than closely related contemporaries from lower latitudes. These results suggest that cold climates played little or no role in the evolution of dinosaur gigantism or in constraining the size of Mesozoic mammals, and in turn provides support for climate as the mechanism underpinning Bergmann's rule. Our approach further showcases the value of the fossil record as an independent resource for testing general principles in ecology and evolution.

Technical Session 16: Hoofed Mammals (Saturday, November 5, 2022, 8:00 AM)

EVOLUTIONARY RATE ANALYSIS OF DENTITION REVEALS COMPLEX ASSEMBLY OF EQUID MOLAR APPARATUS

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The inhibitory cascade (IC) is a developmental model that predicts relative molar proportions in placental mammals. Our previous work using a global compilation of published tooth size measurements of fossil and modern Equidae suggested temporal coupling between relative lower molar sizes and hypsodonty across equids concurrent with the spread of grassland ecosystems in the early Miocene. In order to further investigate this pattern and elucidate the relationship between phylogeny and relative molar size, we compiled a supertree of Equidae and dated it using the *cal3* time-scaling method. Into this framework we incorporated a database of linear measures of 554 complete lower molar rows comprising 65 unique species of equids from North America, South America, Eurasia, and Africa, spanning 56 million years of evolution from the earliest Eocene to the present. We then implemented reversible-jump Markov Chain Monte Carlo (RJMCMC) methods to examine shifts in evolutionary rates of lengths, widths, and areas of each lower molar across the tree. Preliminary results show that rate shifts in molar area evolution are decoupled with regard to tooth position, with each molar exhibiting rate shifts at different times and phylogenetic positions. This introduces additional complexity to the assembly of the horse dental apparatus, revealing a step-wise evolution of molar size as equids assumed new ecological niches.

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

OBSERVATION OF CLAW USE OF THE RED-LEGGED SERIEMA (*CARIAMA CRISTATA*) AND ITS IMPLICATION FOR THE FUNCTION OF DEINONYCHOSAUR “KILLING CLAWS”

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The red-legged seriema (*Cariama cristata*) is unique among extant birds in that they possess a prominent recurved sickle claw on the second pedal digits. These claws are outwardly highly similar to the claws of the extinct deinonychosaurs and basal avialans, and probably convergently evolved due to similar lifestyle/feeding habits, i.e., cursorial, mostly ground-dwelling, and carnivorous. Thus, the way in which seriemas use their claws has the potential to shine additional light on how deinonychosaurs, such as *Velociraptor* or *Troodon*, used theirs. Though formerly thought of as slashing weapons, it has been hypothesized in recent years that deinonychosaurs used their claws to pin and grasp rather than slash as has previously been hypothesized and popularized. This newer hypothesis has

been called the Raptor Prey Restraint (RPR) hypothesis. Our observations of claw use in simulated feeding behavior of red-legged seriemas at the Wildlife World Zoo, Aquarium, and Safari Park in Phoenix, AZ are consistent with the RPR hypothesis. The seriemas were observed using their feet, with special preference given to Digit II, to pin objects, which are then pulled at with the beak. Given the high degree of similarity between the claws of seriemas and the claws of deinonychosaurs, as well as their shared paravian ancestry and similar predatory cursorial lifestyles, it is likely that seriemas are among the best extant proxies for deinonychosaur claw use. This study not only highlights previously unreported specifics of seriema feeding behavior, i.e. the preferential use of their Digit II claws to pin objects, but also serves to highlight the significance of this claw use to understanding that of deinonychosaurs. That an animal with a similar niche and similar Digit II “killing claws” uses said claws in a manner consistent with the hypothesized claw use in deinonychosaurs, is further evidence that the RPR hypothesis is most likely the best hypothesis for the function of the Digit II “killing claws” of deinonychosaurs.

Technical Session 2: Paleoecology (Wednesday, November 2, 2022, 8:00 AM)

FIRST STEPS UNDER DURESS: ECOLOGICAL EVACUATION, EXPANSION AND EXCLUSION FOLLOWING THE END-DEVONIAN MASS EXTINCTION

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The end-Devonian mass extinction (EDME) significantly impacted vertebrates, removing major groups like placoderms and creating a bottleneck in the evolution of surviving clades. Subsequent diversifications include the origins of actinopterygian and tetrapod crown groups and their ecological expansion. However, the structures of Devonian-Carboniferous ecosystems are not well understood. We present initial results from an integrative investigation of Late Devonian-Mississippian ecosystems, including application of the Cascading Extinctions on Graphs (CEG) model to evaluate food web resilience.

Placoderms occupied many marine large predator niches, which remained vacant post-EDME. Chondrichthyans retained similar body size maxima, and actinopterygians diversified greatly at small body sizes. Durophagy in both groups increased, likely supported by post-EDME diversifications of microinvertebrates, echinoderms, malacostracans. The end result is that post-EDME food webs

skew towards smaller size and lower-level consumers, a structure characteristic of modern ecosystems. In the CEG analyses, pre-EDME marine food webs have a wider range of model extinction at a given perturbation than post-EDME food webs and have a substantially lower collapse threshold. This suggests that pre-EDME marine ecosystems were less resilient, and the loss of both marine and nonmarine placoderms further suggests that the change in ecosystem structure was due to the loss of placoderms as a clade, rather than a loss of apex predators.

In continental ecosystems, despite increasing diversity of terrestrial arthropods and the arrival of tetrapods, known terrestrial activity remained at the margins of aquatic activity. The divergence of the lissamphibian and amniote lineages then likely took place in an aquatic context with multiple independent terrestrialization events. It is possible that rather than being 'pulled' onto land, small tetrapods may have been 'pushed' out of the water by larger aquatic tetrapods and fish forced into terrestrial niches to avoid competition. This is consistent with the coexistence of (semi)aquatic large and terrestrial small crown tetrapods at East Kirkton, and the lack of larger terrestrial tetrapods until well into the Pennsylvanian. Overall, these results illuminate a variety of interactions between environment, phylogeny, and community ecology in the evolution of post-Devonian vertebrate ecosystems.

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

REDESCRIPTION OF THE NODOSAURID (DINOSAURIA:ORNITHISCHIA) SKULL SPECIMEN FROM THE MIDDLE CRETACEOUS HIKAGENOSAWA FORMATION (ALBIAN-CENOMANIAN) OF HOKKAIDO, JAPAN.

Oyabu, Shumpei¹, Kobayashi, Yoshitsugu²

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A partial ankylosaur skull (MCM A522), consisting of a partial left occipital region and atlas, eleven isolated teeth and some osteoderms, was reported from the marine Upper Cretaceous Hikagenosawa Formation (Cenomanian) of Hokkaido Prefecture in Japan. A previous study described elements, partially covered by matrix, and concluded that it belonged to Nodosauridae on the basis of some dental characters.

In this study, the Hokkaido specimen is CT-scanned to visualize bone morphology in the matrix. Three dimensional reconstructions allow us to observe the shapes of the neural arch of the atlas, the junction of the occipital condyle and the atlas body, the medial space of the lateral temporal fenestra and orbit, and the lateral part of the braincase. The presence of the developed bone that corresponds to the orbital floor and the beginning of the nasal cavity wall is identified. Two teeth

with exposed only crowns are completely recovered up to the root tips. The part of the brain endocast with inner ear, internal carotid artery and possibly the occipital vein are also restored from the braincase. Furthermore, many ossicles (tiny osteoderms) are preserved in the matrix.

Identified features of the atlas, teeth and semicircular canals are similar to those of nodosaurids, whereas the presence of the developed orbital floor bone is rare for this family. Our phylogenetic analysis confirms the Hokkaido specimen belongs to Nodosauridae and forms a monophyly with some derived North American taxa (*Pawpawsaurus*, *Nodosaurus*, *Niobrarasaurus*, *Borealopelta*, and *Ahshislepelta*).

Funding Sources Scholarship for Nitobe College Honors Program for Graduate Students from Hokkaido University Frontier Foundation.

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

NEW INFORMATION ON THE CARNIVOROUS DINOCEPHALIAN *PAMPAPHONEUS BICCAI* (ANTEOSAURIDAE: SYODONTINAE) FROM THE LATE PERMIAN OF BRAZIL

Paes Neto, Voltaire D.¹, Costa Santos, Mateus², Fabrício Machado, Arielli¹, Schultz, Cesar², Rodrigues Simões, Tiago³, Cisneros, Juan⁴, Pierce, Stephanie E.³, Lima Pinheiro, Felipe¹

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The Rio do Rasto Formation comprises one of the most relevant South American late Permian (Guadalupian) tetrapod records. It is known from several localities from three States of Brazil, with a faunal content mainly composed by temnospondyls, synapsids and an abundant pareiasaur specimens. The carnivorous anteosaurid *Pampaphoneus* is the single named representative of the Dinocephalia in South America, thus far based solely on a diagenetically deformed skull (UFRGS-PV-0386-P), collected at Boqueirão Farm Site, São Gabriel, Southern Brazil. Here we present a new specimen (UNIPAMPA-759) collected from the same site, comprising a nearly complete articulated three-dimensional skull and a few disarticulated postcranial elements. It shares with the holotype all the proposed diagnostic features for *Pampaphoneus*, such as four teeth in the premaxilla, and fills important missing data from previous phylogenetic datasets. The new specimen also reveals intriguing new details of *Pampaphoneus* osteology, like the presence of a conspicuous antorbital depression, a feature also shared with early divergent anteosaurids (e.g. *Sinophoneus* and *Archeosyodon*) and other syodontine

anteosaurids (e.g. *Syodon*), but absent or less marked in all anteosaurine anteosaurids. The specimen has nine post-canine dentary teeth that present serrations on both their mesial and distal carina. Marked striations are also present on at least the dentary incisors, forming a 'scaloped' surface, similar to the early-branching anteosaurid *Archeosyodon*. The vomers are well preserved, with the typical anteosaur 'scroll-like' ridges visible in ventral view. These ridges are straight and ventrally projected, unlike the medially curved condition displayed by *Syodon*, and resembling those of *Archeosyodon* and *Australosyodon*, which were originally thought to be taphonomically deformed. All these new features corroborate the position of *Pampaphoneus* as the earliest-diverging syodontine anteosaur, but further efforts are needed to understand the phylogenetic framework of these early therapsids within synapsids more broadly phylogenetic datasets. This new specimen also preserves an almost complete braincase and set of palatal bones (including large ventrally expanded pterygoid lateral process), offering us future perspectives into *Pampaphoneus* sensory and feeding anatomy.

Funding Sources We thank Harvard's Lemann Brazil Research Fund, CNPq (316811/2021-1) and CAPES 001 (88887.483713/2020-00).

Technical Session 15: Theropods (Saturday, November 5, 2022, 8:00 AM)

THE CONSTRAINTS OF GIGANTISM IN THE FUNCTIONAL MORPHOLOGY OF THE CARCHARODONTOSAURID THEROPOD DINOSAURS METATARSUS

Palombi, Damiano

Museo Paleontologico Ernesto Bachmann, Villa El Chocón, Neuquén, Argentina

Bipedalism is the form of terrestrial locomotion that appeared last in evolution and is, in terms of biomechanics, one of the most complex for an animal. The Carcharodontosauridae are among the largest theropod dinosaurs and therefore have some of largest body masses among bipedal and digitigrade animals. However, the foot osteology and myology of the Carcharodontosauridae theropods are poorly known, due to the fragmentary nature of the known materials and the absence of complete hindlimbs in derived members of the clade (Carcharodontosaurinae). The specimen MMCh-PV 65 was found in the lower levels of the Huincul Formation (Cenomanian-Turonian), in the locality of Las Campanas, near Villa El Chocón (Neuquén, Argentina). It is a derived Carcharodontosaurinae and retains complete and exceptionally preserved feet, providing an opportunity to study novel osteological elements and integrate inferences on soft tissue, musculature, and ligament reconstruction. On the basis of the osteological observations, MMCh-PV 65 has a proportionally shorter and more robust foot than related but smaller taxa, such as *Allosaurus*, *Sinraptor* and *Concavenator*. This

tendency to have more robust metatarsals, although not constricted together as in the arctometatarsal condition, has led to the development of powerful musculature and extensive ligament insertions. Compared to other members of Allosauroidea, the metatarsal joint offers a large intermetatarsal articulation surface with a greater insertion surface for ligaments. A large rugosity marks the distal intermetatarsal articulation surfaces between Mt II and Mt III, indicating that the intermetatarsal ligament distribution is not limited to the proximal epiphysis, as in *Allosaurus*. The lateromedially unconstricted third metatarsal also suggests a more active role of the musculature in ensuring robustness, a view supported by a greater degree of fleshy muscle insertion sites on the metapodial bones, in comparison with the condition observed in Tyrannosauroidea. This complex of characteristics, morphologically basal within Tetanurae but still highly functional to weight support, represents the cursorial to graviportal continuum that allowed Allosauroidea members to reach conspicuous dimensions, highlighting the role of morphofunctional limitations in the development of gigantism in bipedal dinosaurs.

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

AN ASSEMBLAGE OF DIAPSID REPTILES FROM THE MIDDLE PERMIAN OF SOUTH AFRICA AND THE EARLY HISTORY OF PAN-LEPIDOSAURIA

Panigot, Eldon A.¹, Petermann, Holger¹, Rubidge, Bruce S.², Bever, Gabriel S.³, Lyson, Tyler R.¹

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The systematics of early reptiles and especially their relationships to the crown radiations remains a point of considerable ambiguity and research interest. The inherent difficulties of establishing early stem taxa for any total group are compounded here by a relative scarcity of well-preserved specimens from the Permian and early Triassic. We describe a remarkable assemblage of five diapsid reptiles from the middle Permian Endothiodon Assemblage Zone (256-259 million years old) of the Karoo Basin, South Africa, and test hypotheses regarding their phylogenetic relationships. The skeletons are mostly articulated and preserved together in a fine-grained sediment interpreted to be a burrow infill. Among the assemblage, a single skull is preserved which was microCT-scanned and digitally segmented using ORS Dragonfly. The specimen has small upper temporal fenestrae and larger lower temporal fenestrae that lack a lower temporal bar. A large suborbital foramen is present. Tabulars and postparietals are absent and the quadrate is only weakly bowed. The specimen shares a number of features that support an affinity with early pan-lepidosaurs such as *Paliguana whitei*. These features include the lack of a pineal foramen,

and a reduced lacrimal, presence of a quadratojugal foramen, and subpleurodont dentition. The relative scarcity of tangible details from the lepidosaur stem has long been recognized as an important driver of phylogenetic uncertainty within crown reptiles, creating problems for polarizing characters and addressing other important questions, such as the origin of turtles. In this regard, these new Karoo specimens possess considerable heuristic potential.

Technical Session 9: Mammals (Friday, November 4, 2022, 8:00 AM)

HUMAN-MEGAFUNA INTERACTION IN SOUTH AMERICA: DEEP INVESTIGATION OF CULTURAL ORNAMENTS MADE FROM GIANT SLOTH BONES IN CENTRAL BRAZIL, LATE PLEISTOCENE

Pansani, Thais R.

PPGERN, Universidade Federal de Sao Carlos, Sao Carlos, SP, Brazil

The relationship of early humans with now-extinct megafauna in the Americas during the Pleistocene remains hotly debated. The Santa Elina rock shelter in Central Brazil is an important site in this scenario, with a rich stone tool industry in association with extinct giant ground sloth remains (*Glossotherium* sp.) in two stratigraphic units of the Late Pleistocene (dated ~ 13,000 and ~27,000 BP). Among thousands of dermal ossicles (i.e., osteoderms) studied, three were modified into personal ornaments. In this research, they were deeply investigated for the first time. Images were taken with a digital camera, stereomicroscope, scanning electron microscopy, UV/visible photoluminescence, and synchrotron-based microtomography. Traceological analysis of the bone surface modification present on these osteoderms suggest human manufacturing, evidenced by the presence of scraping marks, incision marks, intentionally polished and varnished surface, use-wear traces, and microbreakages from stone tool use during the creation of hole perforations for use as ornaments. Other taphonomic traces of paleoecological interactions are also present (i.e., rodent gnawing, trampling marks, oxide incrustations). The ornament holes are worn, and the smoothed characteristics around the holes and attachment systems suggest intensive use-wear. The uniform contrast revealed by photoluminescence images indicates that the bone, the anthropic marks, and the perforation holes have the same chemical composition, indicating that the human modifications occurred when the osteoderms were fresh, not fossilized (~27,000 BP). This research provides strong evidence for human interaction with ground sloths in the Late Pleistocene in central Brazil, and contributes to the debate on the human role into the Late Quaternary extinction (LQE) in the Americas. The artistic expression of early humans through the production of cultural ornaments made with animal bone material during the Late Pleistocene supports the hypothesis of human occupations in the Americas during the Last Glacial Maximum (LGM).

Funding Sources Fundings: CNPq [process number 141078/2019-7]; CAPES [process number 88887.569989/2020-00]

Technical Session 2: Paleoecology (Wednesday, November 2, 2022, 8:00 AM)

ECOLOGICAL NICHE MODELING AND STABLE ISOTOPE ANALYSIS PROVIDE INSIGHT INTO DIETARY VARIATION OF MAMMOTH (*MAMMUTHUS*) ACROSS ENVIRONMENTS IN NORTH AMERICA

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The geographic range reflects the ecological niche, with boundaries constrained by the interplay of a taxon's habitat requirements, availability of resources, competition, and behavior. Although infrequently scrutinized, behaviors that enable persistence, such as feeding type and specificity, may vary across niche (and geographic) space in a predictable fashion. Despite having evolved adaptations enabling the consumption of grass (e.g., extreme hypsodonty), mammoth (*Mammuthus*) were widespread across many environments with variable diets ranging from mixed-feeding to grazing. We used ecological niche modeling (in Maxent) to ask which environmental conditions were most suitable (associated with high probability of occurrence) for mammoth during the late Pleistocene (~20 – 11.7 ka). We then used stable isotope analysis of $\delta^{13}\text{C}$ from tooth enamel to ask how mammoth diets varied in relation to suitability.

The model was trained using occurrences from published radiocarbon dates of mammoth and environmental variables from the Paleoclim dataset. Environmental reconstructions and occurrences come from the Last Glacial Maximum (26-19 ka, N = 20), Heinrich Stadial 1 (17.0-14.7 ka, N = 10), the Bølling-Allerød (14.7-12.9 ka, N = 25), and Younger Dryas (12.9-11.7 ka, N = 7). We included only reliable, direct dates from mammoth remains found in geologic contexts representing true occurrences. The final, tuned model was divided into three domains. The least suitable areas had probabilities of occurrence below the minimum assigned to training occurrences. Areas above the tenth percentile threshold for known occurrences were most suitable. Areas with probabilities between these thresholds were classified as intermediate. Greater suitability was associated with lower average temperatures during the driest quarter, lower precipitation of the driest quarter, and higher precipitation of the warmest quarter.

An independent dataset of $\delta^{13}\text{C}$ from mammoth tooth enamel was assembled from literature values, with localities assigned to the time bins of our study. Samples were from latitudes below 37 degrees, where $\delta^{13}\text{C}$ serves as a proxy for relative

consumption of C3-browse and C4-grasses. Individuals sampled from the most suitable (N = 15, 4 localities) and intermediately suitable areas (N = 55, 12 localities) consumed significantly more grass (Dunn's Test, $p < 0.05$) than individuals from least suitable areas (N = 17, 11 localities).

Funding Sources This work was funded by the National Science Foundation (EAR 1725154).

Technical Session 5: Amphibians & Early Reptiles (Thursday, November 3, 2022, 8:00 AM)

EXCEPTIONALLY PRESERVED LARVAL STEM TETRAPODS FROM MAZON CREEK

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Tetrapoda consists of two major lineages, Amniota and Lissamphibia. Each of these is characterized by novel life histories (the amniotic egg and biphasic metamorphosis, respectively) that serve as adaptations to a life on land. Although it is clear that amniote embryogenesis is novel within vertebrata, it is unclear whether amphibian metamorphosis is similarly novel or whether amphibian-like biphasic metamorphosis was present in the earliest tetrapods. We here bring direct fossil evidence to this debate by reporting on exceptionally-preserved stem-tetrapod fossils from the Mazon Creek Lagerstätte at the late embryonic/early larval transition. Preserved soft tissue structures include body outline, extraoral tissues, retinal pigments, and axial muscle blocks. Stem-tetrapod larvae exhibit precocial cranial and axial ossification, particularly of tooth-bearing bones of the palate and oral margin, but delayed morphogenesis of the pectoral and pelvic appendages and absence of dermal scales. Conspicuous abdominal yolk, lack of gut contents, and absence of microwear on the teeth suggests that one embryo had not yet begun to feed at time of death, and indicating that egg and embryo sizes of early tetrapods were relatively large. Absence of external gills, which are widely preserved in definitive stem-lissamphibians from the same locality, strongly suggests that stem-tetrapods lacked a lissamphibian-like metamorphosis (tadpole stage), and that metamorphosis did not play an important role in the initial tetrapod terrestrialization process. This also bolsters an emerging recognition that thyroid-mediated metamorphoses in diverse vertebrate lineages evolved convergently.

Funding Sources JDP is an NSERC Banting Postdoctoral Fellow. AM is a Peter Buck Smithsonian Postdoctoral Fellow

Romer Prize Session (Thursday, November 3, 2022, 8:00 AM)

TRACING COORDINATED TRENDS AND DRIVERS OF MAXIMUM BODY SIZE IN CENOZOIC TERRESTRIAL VERTEBRATES

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Body size is a key trait influencing vertebrates' trophic ecology and environmental adaptation. Maximum size trends over deep time provide information about relative niche evolution between taxa. However, such trends in the Cenozoic have previously been studied only for mammals, whose size maxima increased dramatically as they diversified to fill large-bodied terrestrial niches left vacant after the extinction of the non-avian dinosaurs. I used both traditional correlation tests and a novel approach employing stochastic differential equation modelling to test whether Cenozoic reptiles evolved to larger sizes concordantly with mammals or competed with mammals for large-bodied niches. I compiled the first dataset of size maxima for each Cenozoic sub-epoch covering all extant reptile groups—crocodylians, turtles, birds, lizards, and snakes—based on specimen measurements, published mass estimates, and regression equations. In addition to modelling biotic interactions between the time series for each higher-order clade, I investigated abiotic drivers of size change by testing for correlative and causal relationships between reptile maximum size and paleoclimate variables over time, because body size and temperature are functionally linked in poikilotherms. My results show that across archosaur groups and terrestrial mammals, maximum size peaks in the Late Miocene. Although this size increase coincides with global cooling, differential equation modelling does not support temperature change as a proximate causal driver of maximum size evolution in any clade. Models show greater support for causal relationships between the clades' size trends, indicating that interactions within vertebrate communities exert a greater influence on body size change than environmental drivers do. Reptile size maxima positively track mammal size trends over time, except for in snakes, whose maximum size occurs in the Middle Paleocene. Models support a negative causal relationship between mammal and snake size, with increasing mammal maxima forcing snakes to smaller body sizes. The maximum size of flightless birds is strongly negatively influenced by snake size, suggesting that snake predation constrains bird size. Examining trait change data across deep time reveals shifting ecological roles between clades, and my results support evolution to large size responding to regional trophic pressures, rather than to global-scale climatic transitions.

Funding Sources Funded by the Harvard Herchel Smith Scholarship at Emmanuel College, Cambridge University Worts Travelling Scholars Fund, and Emmanuel College Panton Trust Grant

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

THE SYSTEMATICS AND PALEOECOLOGICAL SIGNIFICANCE OF A NEW GENERALIZED EUSUCHIAN FROM THE EARLY PALEOCENE OF NORTH DAKOTA

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Borealosuchus is a group of large, generalized North American eusuchians of Late Cretaceous through middle Eocene age in North America. Most were formerly classified as species of *Leidyosuchus* or *Diplocynodon*, but whereas *Leidyosuchus* (Campanian, North America) and *Diplocynodon* (Paleocene through Miocene, Europe) are a basal alligatoroids, species later referred to *Borealosuchus* have adopted various positions close to the root of Crocodylia, in spite of their overall resemblance. Here, we discuss a new eusuchian from the early Paleocene Fort Union Formation of North Dakota that challenges these previous results and calls monophyly of *Borealosuchus*, as currently construed, into question.

The new form is based on a partial skull and jaws, with additional craniomandibular remains being referable. It bears a striking outward resemblance to both late Maastrichtian *Borealosuchus sternbergii* and Paleocene *Diplocynodon remensis* and preserves a confusing combination of plesiomorphic and derived states. In particular, the quadrate foramen aëreum of the Fort Union form is located on the dorsal rather than the dorsomedial surface of the quadrate ramus. Maximum parsimony analyses recover trees supporting three distinct positions for the new form – within *Diplocynodon*, basal within *Borealosuchus*, or as an allodaposuchid.

A re-evaluation of the morphology of early members of *Borealosuchus* from the Western Interior suggests they might be basal alligatoroids. However, later western forms (e.g. *Borealosuchus wilsoni*) and fossils referred to *Borealosuchus* from the Atlantic Coastal Plain (e.g. *B. threeensis*) may not actually fall within *Borealosuchus* and instead be eusuchians close to the ancestry of Crocodylia.

These results bear not only on our understanding of the morphology of the ancestral crocodylian, but also on the historical biogeography of early alligatoroids in North America and Asia.

Funding Sources University of Iowa Department of Earth and Environmental Sciences

EXCEPTIONALLY WELL-PRESERVED SOFT TISSUE REMAINS IN A THEROPOD EGG/EMBRYO FROM THE LOWER CRETACEOUS CLOVERLY FORMATION OF CENTRAL MONTANA

Parsons, William L., Parsons, Kristen M.

Independent researcher, South Wales, New York, United States

Associated egg fragments, skeletal, and soft tissue remains representing one isolated egg and embryo of a small theropod taxon were recovered from a site in the Unit VI stratum of the Lower Cretaceous Cloverly Formation in central Montana. The egg is approximately 9.5 cm long and slightly compressed. This is the length of an egg from the taxon, *Deinonychus antirrhopus*. It was broken into six large fragments that were recovered over a period of three years. This egg was found within a thick layer of bentonite which was probably not the original matrix of its nesting site. Due to the acidic nature of this volcanic matrix almost none of the cortical surface of the egg was preserved. Some regions of the sub-layers of the eggshell remain intact. Much of the embryo itself is presented within a natural cross-sectional break between two of the larger fragments, but further smaller portions of the embryo appear in smaller pieces. It is curved around in a manner akin to the appearance of many modern bird embryos. The skull, neck, thoracic and hip regions are clearly defined. Many other skeletal elements are made clear in the CT scans that were conducted. Fragments of skin appear in several places on both of these two larger cross sections. Dermal denticles on the surface of the preserved skin resemble the feather buds on modern avian embryos. An ovoid organ near the base of the neck has two separate chambers outlined; this we conclude to be the heart. The esophagus is defined by a white calcite infilling that closely parallels the length of the cervical vertebrae. The caudal musculature is defined as a shadowy outline that emerges from beneath the hip region and curls upward almost contacting the premaxilla. Whether it terminates at that point or whether it dives deeper into the egg matrix is difficult to determine due to undefined soft tissue obscuring the imagery in the CT scans. There is a gastric bubble that was formed in the abdominal region, and the braincase exploded or at least fragmented up and away from the rest of the skull. These expanded soft tissue regions of the embryonic body indicate a rapid heating, possibly due to being buried in hot volcanic ash. The sudden heating and immediate burial in a sterile volcanic matrix may explain the remarkable degree of preservation. The potential for further soft tissue/molecular research seems apparent, but the delicate nature of this soft tissue preservation makes methods such as acid prepping unadvisable.

Funding Sources Self-funded

Technical Session 10: Soft Tissues & Taphonomy (Friday, November 4, 2022, 8:00 AM)

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

QUANTIFYING VARIATION IN THE MARGINAL DENTITION OF A MALERISAURINE (ALLOKOTOSAURIA) FROM THE UPPER TRIASSIC CHINLE FORMATION OF ARIZONA SHOWS STATISTICALLY DISTINCT MORPHOLOGIES WITHIN DIFFERENT TOOTH-BEARING ELEMENTS

Patellos, Emily¹, Kligman, Ben², Marsh, Adam³, Stocker, Michelle², Parker, William G.³, Nesbitt, Sterling J.²

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Isolated teeth are common fossils due to the strength of enamel and their abundance within an individual. However, their utility for taxonomic identification is limited because tooth shape can be extremely variable, even within a single organism. Here we explore: 1) can species identifications be made from isolated tooth crowns?; and 2) can quantitatively-derived tooth anatomy be used to better reconstruct paleoecology? To address these questions, we utilized a newly discovered malerisaurine azendohsaurid from the Chinle Formation of Petrified Forest National Park, Arizona, as a case study in a quantitative morphometric analysis of dental anatomy. This species was chosen due to its presence in a monodominant bonebed and its clearly heterodont dentition, unique to this group of animals within its clade. The anterior teeth of the maxilla are labiolingually compressed with a sharply angled recurvature. The dentary and posterior maxillary teeth are spade-shaped, with little curvature at the apex; the teeth in the dentary are less compressed than the maxillary teeth. Teeth in the premaxilla are long and conical, with a subtle distal recurvature. We used linear measurements to quantitatively describe the overall dentition found within 10 marginal tooth-bearing elements from multiple individuals, sampling from the premaxilla, maxilla, and dentary. Those measurements were analyzed in Python using Seaborn and Scikit Learn package to calculate a principal component analysis (PCA), sparse PCA, and K mean cluster analysis to identify the best method for determining patterns in tooth morphologies in their respective dentigerous element. The most variation seems to be explained by the apical length (39.5%), crown height (15.3%), and crown base length (10.6%), respectively, as according the PCA's. Sparse PCA shows potential in that it can take noisy PCA data and determine more distinct morphological clusters by element. K mean cluster analyses on PCA data can further distinguish morphotypes, providing a centroid that may be useful when comparing anatomy of isolated crowns. Using a combination of PCA and K mean cluster analysis can distinguish shape in teeth from the premaxilla, maxilla, and dentary within this species. In the future, isolated teeth from this quarry may be identified to this malerisaurine and their bony element of origin. Similar methods may be useful for identifying isolated crowns in multi-taxa bonebeds.

Funding Sources David B. Jones Foundation

Technical Session 16: Hoofed Mammals (Saturday, November 5, 2022, 8:00 AM)

AN EARLY MIOCENE ENAMEL PROTEOME OF AN EARLY-DIVERGING RHINOCEROTID FROM CANADA'S HIGH ARCTIC

Paterson, Ryan S.¹, Cappellini, Enrico¹, Mackie, Meaghan², Patramanis, Ioannis², Rybczynski, Natalia³, Gilbert, Marisa³, Fraser, Danielle⁴, Liu, Shanlin⁵, Ramos-Madrigal, Jazmin⁶, MacPhee, Ross⁷

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In the past decade, ancient proteins have emerged as a valuable source of data for inferring phylogeny in deep-time fossils. However, the oldest ancient proteins for phylogenetic inference have only been obtained from the Pliocene (3.5 Ma). Here, we push back the geological age for obtaining phylogenetically-informative ancient biomolecules to the Early Miocene (22-24 Ma), represented by enamel protein sequences of an early-diverging rhinocerotid from Canada's High Arctic.

Located within the Haughton impact crater (75°N, Nunavut, Canada), the Haughton Formation comprises the remnants of a large, post-impact lacustrine deposit of Early Miocene age. The highly endemic fauna of the Haughton formation consists of several mammals, including a well-preserved rhinocerotid. These fossils, found in the active layer atop the permafrost, have been spared from the harshest effects of diagenesis. Thus, they serve as an appropriate test of ancient biomolecular preservation.

Recently, palaeoproteomics has allowed for the retrieval of phylogenetically-informative protein sequences from dental enamel. We applied these enamel extraction protocols to enamel fragments of a rhinocerotid from the Haughton Formation.

Our extraction protocols were successful in recovering 327 unique peptides, covering 1101 spectra, provisionally spanning at least 232 amino acids and representing at least six enamel proteins (AHSG, ALB, AMBN, AMELX, AMTN, ENAM). The degree of protein preservation in this rhinocerotid specimen is comparable to that of Early

Pleistocene enamel from tropical climates, and permits its inclusion in a phylogenetic analysis of enamel protein sequences.

To investigate the phylogenetic relationships at the base of Rhinocerotidae, protein sequences were translated from genomic data of *Elasmotherium sibiricum*, and incorporated into our database searches and phylogenetic analyses, complementing the suite of extant and extinct perissodactyls already available. Phylogenetic analysis using Bayesian tip-dating, across 22 perissodactyl and cetartiodactyl taxa and 2685 total amino acids, identified the High Arctic rhinocerotid as the earliest diverging rhinocerotid in our analysis.

This work further demonstrates the power of ancient enamel proteins in elucidating phylogeny and taxonomy of taxa in deep-time. We hope these findings encourage further vertebrate palaeontological fieldwork in cold-temperature sites with taphonomic conditions favourable to biomolecular preservation.

Funding Sources This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement (No. 861389).

Technical Session 12: Rodents & Quaternary Mammals
(Friday, November 4, 2022, 1:45 PM)

MOLECULAR AND MORPHOLOGICAL ASSESSMENTS OF MASTODONS OF THE AMERICAN FALLS RESERVOIR, IDAHO: AMERICAN? PACIFIC? BOTH?

Peacock, Brandon R.¹, Karpinski, Emil², Widga, Chris³, Boehm, Andrew⁴, Kuch, Melanie⁵, Murchie, Tyler J.⁵, Thompson, Mary E.¹, Poinar, Hendrik N.⁵

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Recent advancements in isolating and sequencing genetic material from fossil specimens have allowed paleontologists to refine our understanding of the population dynamics of extinct organisms and attempt to reconcile morphological observations with underlying genetic diversity. The American mastodon (*Mammuth americanus*) is an icon of the North American Pleistocene megafauna, and a member of the well documented fauna of the American Falls Reservoir (AFR), southeastern Idaho. Continental-scale phylogenetic analyses of mitochondrial DNA suggest that *M. americanus* followed the expansion and contraction of its preferred habitat from the mid- to high-latitudes of North America as ice sheets ebbed and flowed, with mastodons from Beringia and the Yukon forming a clade (Clade Y) of relatively low genetic diversity

during the last interglacial (MIS 5). In 2019, the Pacific mastodon (*M. pacificus*) was erected based on distinctive molar morphology and the absence of mandibular tusks, with referred specimens from California and a single Smithsonian specimen from AFR. We sequenced mtDNA from two AFR specimens of *Mammuth sp.* (worn, isolated molars) in the Idaho Museum of Natural History (IMNH) and found them within Clade Y, itself nested deeply within other populations of *M. americanus*. This result is consistent with the MIS 5 age approximation of the lower AFR Formation. Additionally, we documented the absence of mandibular tusks in half of the *Mammuth* mandibles in the collections of the IMNH, a pattern consistent across a range of body sizes. Unfortunately, none of the mandibles preserve the necessary molar morphology to refer them to *M. pacificus*. Taken together, we find no additional positive evidence for the presence of *M. pacificus* from AFR, but also cannot yet demonstrate that the tuskless mandibles are *M. americanus*. Coarse stratigraphy and historical collecting at AFR do not preclude the possibility the two species coexisted in SE Idaho, or inhabited the region iteratively as climate varied. We may expect future aDNA studies incorporating *M. pacificus* specimens to find an *M. pacificus* clade within the diversity of temperate *M. americanus* populations, or as sister to *M. americanus* all together.

Funding Sources NSERC: PGSD3-518942-2018 to EK, NSERC Discovery: 4184-15 to HNP, Idaho Museum of Natural History

Colbert Prize Session

AN INVESTIGATION OF CENOZOIC LATITUDINAL DIVERSITY GRADIENTS FROM A MORPHOLOGICAL PERSPECTIVE: A CASE STUDY IN NORTH AMERICAN RODENTS

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Diversity gradients describe species diversity change across geographic and environmental gradations. One of the most well-known is the latitudinal diversity gradient (LDG) which characterizes the decline in species richness with increasing latitude and distance from the equator. Modern LDGs are ubiquitous across the tree of life and have been detected in both terrestrial and marine organisms, however, their perseverance through geologic time is debated, and previous work has found LDGs to be a recent phenomenon. These gradients are often examined from a perspective of taxonomic diversity, which is more sensitive to taphonomic bias in the fossil record than diversity of morphology or ecology. In this study, we take the approach of considering LDGs from a morphological perspective. We investigate the geographical distribution of morphological diversity throughout the Miocene and explore the timing of diversity trends. To do this, we obtained North American rodent occurrence and body

mass data from the MioMap and Paleobiology databases. We stratified the data by North American Land Mammal Age (NALMA) and placed the data into 3° longitude by 3° latitude bins and made comparisons of morphological diversity, along with average body mass and species richness. We capture morphological diversity through a measure of mean distance from the centroid in body mass. We find that morphological diversity increases through time as well as with latitude, and does so in a stepwise fashion, with higher latitudes generally achieving high morphological diversity in earlier time periods than lower latitudes. Species richness, on the other hand, follows this same trend but peaks at a lower latitude than morphological diversity. We find that both morphological and taxonomic diversity peak during the Barstovian NALMA at nearly all latitudes. This peak overlaps with the Middle Miocene period of significant climate warming and tectonism in North America, which points to the intricate relationship between landscape homogeneity and biological diversity. Past work has revealed a Late Cenozoic onset of the LDG in mammals. We reaffirm this finding, and add that in rodents in particular, the modern LDG was not present until the Late Miocene at the earliest. We find higher diversity, both morphological and taxonomic, at higher latitudes for much of the Miocene, which suggests that the drivers of LDGs are complex, multiple, and may not be constant through geologic time.

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

PTEROSAUR DEATH POSE PROVIDES INSIGHT INTO TAPHONOMY AND MODE OF MORTALITY

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Pterosaur bones are usually delicate in comparison to other similarly sized vertebrates, however there is a significant record of complete (or nearly complete) articulated pterosaurs preserved in lagerstätte from around the world. This record of exceptionally preserved specimens provides an excellent opportunity to determine what information can be recovered from the body posture in which the pterosaurs were preserved. The posture of preserved articulated fossils has been studied for over 200 years and a range of hypotheses to explain unusual postures have been put forward, with either taphonomic or palaeopathological foci, although differentiating the two root causes of death pose has proven difficult in the absence of large datasets of consistently described specimens.

Here we describe the death pose of 58 exceptionally preserved pterosaurs that were imaged in sufficient detail in the published literature. We use a consistent protocol to capture the orientation of each element in the skeleton with respect to the other elements with which it articulates, as well as a more holistic description of the specimen. The positioning of each

joint is then evaluated as without plausibly modified orientation, with potentially taphonomically modified orientation, with potentially pathologically modified orientation (reflecting an anomalous pose that could not be otherwise explained), or both.

When compared to our previous studies focused on birds and dinosaurs, this dataset of pterosaur fossils showed a similar proportion of specimens with likely taphonomic modification (95+%), but markedly fewer with any pathological modification that corresponded to known archetypes. Particularly noteworthy was the absence of potentially pathologically modified positioning of the pes, which was observed more commonly in birds and dinosaurs. It is presently unclear whether this apparent lack of pathological modification suggests that pathologically influenced death pose was rarer in pterosaurs, that pterosaurian mortality produced different death poses to birds and dinosaurs (due to anatomical or pathological differences) that we have been unable to identify, or whether our original dataset of bird and dinosaur death poses was biased towards pathologically influenced specimens.

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

ARE PINNIPEDS HOMODONT? SHAPE ANALYSES SHOWS A BROAD DIVERSITY OF PINNIPED CHEEK TEETH MORPHOLOGIES.

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Pinnipeds (seals, sea lions, and walruses) are a clade of marine carnivorans that evolved from terrestrial ancestors approximately 27 Ma, in the Oligocene, and have become increasingly aquatic throughout their evolutionary history. Despite having descended from terrestrial mammals, extant pinnipeds lack the complex molars emblematic of mammalian feeding. Extant pinnipeds, which largely feed on fish, do not masticate or process prey with their teeth before swallowing. Consequently, several lineages of extant pinnipeds have a reduced or simplified dentition with incisiform cheek teeth, resulting in pinnipeds sometimes being described as homodont. This trend towards homodonty occurs in other marine mammals, such as whales, and may represent an aquatic adaptation. However, potential links between feeding in an aquatic environment and a simplified dentition remain untested. We quantified cheek tooth shape of extinct and extant pinnipeds and asked whether homodonty is an adaptation to the marine environments using a phylogenetic framework. Our results demonstrate a surprising diversity of dental shapes, but also identify key points of convergence on

similar shapes across all four major pinniped clades. Each clade exhibits a remarkable diversity of dental shapes beyond the simple, incisiform, conical pegs typically associated with homodonty. In addition, we suspect that dental shape is driven by broader feeding ecology which calls into question whether simple, conical teeth are an aquatic adaptation.

Funding Sources CMP is supported by the National Science Foundation, NSF Award #1906181

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

MORPHOLOGICAL VARIABILITY OF THE DENTITION OF THE ORDER CARNIVORA: THE UPPER TEETH UNDERGO MORE TRANSFORMATIONS THAN THE LOWER TEETH

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The dentition performs several functions that are crucial from an adaptive point of view. In the case of carnivores, teeth are mainly used for hunting and food consumption, although they can also be used for other tasks. Since the teeth of the upper and lower jaw are functionally integrated, it is theoretically expected that both would covary simultaneously when adapting to different modes of hunting and feeding. However, since the lower jaw is involved in fewer functions than the skull, the upper teeth may be affected by certain distinctive constraints due to this fact. Here we analyze the morphological disparity of the upper to lower dentition of living and extinct representatives of the family Hyaenidae and Felidae in relation to that observed for other extant families of the carnivorous order (Canidae, Mustelidae, Procyonidae, Ursidae, Eupleridae, Herpestidae and Viverridae). In almost all cases the disparity is greater in the upper dentition than in the lower dentition, both at the order level and within each family. In the case of the felids, this occurs in both Felinae and Machairodontinae. This is also the case for the main ecomorphs defined in the family Hyaenidae throughout its evolutionary history. These results suggest that adaptation to the different niches occupied by the order is obtained mainly by modifying the upper dentition.

Funding Sources Research Group RNM-146 (PAIDI). Projects UMA18-FEDERJA-188 and P18-FR-3193 (Secretaria General de Universidades, Investigacion y Tecnologia, Junta de Andalucia).

Virtual Posters

FEEDING HABITS OF COLUMBIAN MAMMOTH (*MAMMUTHUS COLUMBI*) FROM SANTA LUCÍA IV, STATE OF MÉXICO, MÉXICO

Perez-Crespo, Víctor A.¹, Arroyo-Cabrales, Joaquín², Cienfuegos-Alvarado, Edith¹, Rodríguez-Franco, Susana³, Ortiz -Reyes, Carol Yazmin⁴, Otero, Francisco J¹

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Feeding habits and habitats for 13 Columbian mammoths (*Mammuthus columbi*) from the recent salvage excavations undertaken while the new Mexico City airport “General Felipe Angeles” was under construction, were assayed using isotopic relationships from carbon and oxygen found in dental enamel. Results show that most of the mammoths were mixed feeders, and just one ate C₄ plants, similar to the same pattern found for other animals from this same region and several other areas within the country. In regard to oxygen isotopic values, differences could be due to either the time span in which individuals lived during the late Pleistocene or to a mixing of native and migrant individuals; because of that, strontium isotopic analysis are warranted for identifying those moving from other regions. In addition, radiocarbon dates associated with the individuals would provide support to learn whether individuals were contemporaneous or not.

Funding Sources PAPIIT – UNAM for financial support (grant IN101321) for this study; Posgrado en Ciencias Biológicas and CONACYT for support to SRF (grant 920655)

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

NEW MATERIAL OF THE ENIGMATIC MAMMAL *IDIOMYOMYS*: A LATE SURVIVING NORTH AMERICAN LINEAGE OF BASAL GLIRES?

Person, Jeff J., Boyd, Clint

North Dakota Geological Survey, North Dakota Geological Survey, Bismarck, ND, US, public, Bismarck, North Dakota, United States

Idiomyomys ozziei is a small-bodied mammal known from ten isolated teeth from the Chadronian (Eocene) Raben Ranch local fauna in Nebraska. Those teeth display an unusual morphology that has prevented the confident referral of this taxon to any mammalian order. Screen washing efforts at the Chadronian Medicine Pole Hills locality in North Dakota recovered five isolated teeth referable to *I. ozziei*. Similar efforts at the Whitneyan (Oligocene) Obritsch Ranch locality

in North Dakota produced a single upper molar that closely resembles *I. ozziei*, but may represent a second species. Given the increased number of specimens available for study, we undertook a renewed assessment of the systematic relationships of *Idiogenomys*. All known specimens (excluding the holotype, and two others thought to be lost) were imaged with a micro-CT scanner and the resulting scans were studied digitally and used to print enlarged 3D models of the teeth, improving our ability to identify dental features and wear facets, and for testing hypotheses regarding occlusion. Overall, the teeth are brachyodont and somewhat bunodont, but the lower dentition is also somewhat lophodont, bearing a low paracristid anteriorly and a low postcristid posteriorly. In general morphology, the upper dentition of *Idiogenomys* most closely resembles the teeth of early diverging taxa within *Simplicidentata* situated outside of crown *Rodentia*. It resembles some *alagomyids* in lacking a hypocone and a mesostyle, but bears broad pre- and postcingula similar to those seen in taxa such as *Cocomys* and *Bandaomys*. Most basal glires are known from Asia, with only a single species previously described from North America: *Alagomys russelli* from the Clarkforkian (Paleocene) of Wyoming. We propose *Idiogenomys* represents either a continuation of the *A. russelli* lineage or a second basal glires lineage within North America. Under either scenario, the *Idiogenomys* lineage was unsampled for millions of years prior to the Chadronian, explaining the extreme morphological differences between this taxon and all other basal glires that make more precise resolution of its systematic relationships difficult at this time. However, the expanded geographic and temporal range of *Idiogenomys* revealed by this study indicates this taxon was present throughout a large portion of the Great Plains region of North America, though sampling this small taxon does seem to require intensive screen washing efforts.

Technical Session 14: Squamates & Turtles (Friday, November 4, 2022, 1:45 PM)

A HIGHLY-DIVERSE SQUAMATE FAUNA FROM THE LATE MAASTRICHTIAN OF THE DENVER FORMATION (COLORADO, USA) HIGHLIGHTS HEALTHY ECOSYSTEMS PERSISTED RIGHT UNTIL THE END CRETACEOUS MASS EXTINCTION

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Recent discoveries of remarkable fossil assemblages that bracket the Cretaceous-Paleogene (K-Pg) extinction event, chief among them exceptionally diverse faunal and floral assemblages of the Denver basin, have reinvigorated studies of the ecosystems before and after this defining event in Earth history. This research often focuses on the healthiness of pre-extinction ecosystems and mode and timing of post-extinction ecosystem (re-)assembly. Here, we report a highly-diverse squamate fauna from the late Maastrichtian Ian's Slope locality of the Denver formation, which provides novel

insights into ecosystem health just before the K-Pg mass extinction. Microvertebrate remains cover the full breadth of vertebrate diversity (mammals, dinosaurs, crocodylians, testudines, amphibians, chondrichthyans and actinopterygians, and squamates) and can be placed within ~1 m (~100 ky) below the K-Pg boundary. The fossils are largely found in association with a partial skeleton of the large ornithischian dinosaur *Triceratops* in floodplain or oxbow-lake sediments. To date, ca. one dozen squamate taxa, including a single vertebra of the alethinophidian snake *Coniophis* sp., have been recovered from a single locality. Other finds include a large (>40 mm length) platynotan dentary that may represent the carnivorous *Cemeteryia* sp. and multiple cranial elements (frontals and parietals) of anguid lizards, some of which show similarities with *Odaxosaurus* sp. while others seem to belong to an as of yet undescribed larger-bodied relative. The large number of dentaries that correspond to insectivory, carnivory, and herbivory highlights an ecologically healthy squamate fauna with multiple sympatric species co-occurring right before the second most disruptive mass extinction event in Earth history.

Funding Sources The Lisa Levin Appel Family Foundation; M. Cleworth; Lyda Hill Philanthropies; David B. Jones Foundation; DMNS No Walls Community Initiative.

Preparators' Poster Session

VIRTUAL REALITY AIDED RECONSTRUCTION AND IMMERSIVE INTERNAL ANATOMICAL VISUALIZATION OF VERTEBRATE FOSSILS

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Virtual reality (VR) is a technology that has been used in visualization of deposits in resource geology, surgical training and in the creation of many commercial gaming-centric experiences. Recently, applications have arisen that allow the user to accomplish computer aided design (CAD) tasks in virtual spaces and with virtual manipulation. We outline the potential that integrated VR and CAD methods carry for digitized fossil specimens and their use with digital re-articulation of fossil remains, 1:1 scale visualization, and immersive examination of microanatomy.

Methods - VR Equipment and protocols: We utilize the Oculus (now Meta) Quest II headset and peripherals in conjunction with Gravity Sketch, a VR CAD application, and their Landing pad service and file directory import to deliver mesh data to the headset in the form of a wavefront.OBJ mesh. In initial attempts to use VR in this manner, a digitized false gharial skull (*Tomistoma schlegelii*, published via digimorph.org), was cut into three segments in order to

attempt simple rearticulation. Surface models of theropod dinosaur bone vasculature were constructed and exported from Avizo into our system to test interactive visualization of canal systems.

Results: Re-articulation is rapid when using separated elements, but placing elements in exact positions in VR can prove difficult and time consuming. Placing elements in close proximity and saving the data in this way can prove useful in creating an “exploded” model or in preparation for more detailed desktop-based work.

We interactively present VR results comparing bone vascular systems in tyrannosaur and ornithomimid metatarsals. The adult ornithomimid elements illustrate a vascular network that is far more sparse when compared to that of perinate tyrannosaurs, reflecting slower growth. These anatomical features are visible to the operator in a virtual environment without an exaggerated modification of the source data. This investigation serves as an assessment of the techniques described and their efficiency when compared to traditional methods of digital manipulation where three dimensional imagery is concerned.

Virtual Posters

TRUNK VERTEBRAE OF A LAGERPETID (ARCHOSAURIA: PTEROSAUFOMORPHA) DOCUMENTS VARIATION AND POSSIBLE ANCESTRAL CONDITIONS IN THE VERTEBRAL MORPHOLOGY OF EARLY-DIVERGING ORNITHODIRANS

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As the most ecologically diverse and speciose bird-line archosaurs, dinosaurs and pterosaurs are the subject of intense study and interest. However, understanding their origin and early evolution is complicated by the relative paucity of skeletons of early-diverging ornithodiran fossils. Lagerpetids were a clade of early-diverging ornithodirans sharing morphological traits with both dinosaur precursors and pterosaurs. Many aspects of lagerpetid anatomy are still unknown, including the extent of morphological variation in the axial skeleton. Here we describe eleven vertebrae collected from the Dockum Group of Texas in association with a braincase referred to the lagerpetid *Dromomeron gregorii*. The amphicoelous vertebrae have undivided or subdivided transverse processes set on the neural arch, indicating that they likely belong to the trunk series. The centra are longer than tall, and well-preserved neural arches show prominent centrodiaepophyseal and postzygapophyseal centrodiaepophyseal fossae. Vertebrae estimated to be more posterior in the trunk series are proportionally wider and more robust, with transverse processes in an anteroventral position on the neural arch. All centra lack a rimmed lateral foramen,

in contrast to those of pterosaurs. There is no evidence for slender, anteriorly-inclined neural spines as seen in the close relative *Lagerpeton*. The ventral surfaces of the postzygapophyses are joined by a horizontal plate of variable depth, which connects to a notch between the small and widely-spaced prezygapophyses. The trunk vertebrae of *Dromomeron* possess apparently plesiomorphic character states more similar to dinosaufomorphs than in early-branching pterosaufomorphs. The presence of distinct neural arch fossae in *Dromomeron* is a condition shared with aphanosaurs, silesaurids, and saurischians, but absent in the dinosauriform *Lagosuchus*, ornithischians, and the closely related lagerpetid *Ixalerpeton*. The centra proportions show a similar pattern of distribution among ornithodirans. The morphology documented for *Dromomeron* emphasizes the wide variation in vertebral structure among early bird-line archosaurs, even among closely related taxa within Lagerpetidae.

Funding Sources NSF EAR 1943286

Preparators' Session (Thursday, November 3, 2022, 8:00 AM)

STABILIZATION AND CRATING FOR TRANSPORT OF A LOANED HOLOTYPE *TRICERATOPS* SKULL

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USNM V4928 is the holotype of *Triceratops calicornis* (= *Triceratops horridus*), in the National Museum of Natural History (NMNH) collections. The cranium and lower jaws of the specimen were loaned to the University of Colorado Museum of Natural History (CUMNH) in 1981, where the frill was reconstructed in the museum exhibit space. A wooden base displays the cranium and jaws in articulation, with the specimen supported by external and internal steel armature.

To return the loaned specimen, two advance trips were made by NMNH to CUMNH to assess and measure the specimen and surrounding spaces. As the reconstructed frill was now wider than museum doorways, the challenge was how to crate and remove the specimen with minimal alteration. Preparations included creating technical drawings for crates, mapping reconstructed materials in the specimen, and advance shipment of supplies. A daily schedule of work determined the person-hours required. Arrangements were finalized with campus staff also providing much-needed resources.

To retrieve the specimen, a team of four NMNH staff worked with CUMNH staff over a period of five days. Work was conducted within the museum's Paleo Hall exhibit space. The process to prepare, pack, and crate the specimen included first protecting the surrounding floor and exhibits. Specimen cracks were consolidated, and gaps filled using solutions of Butvar B-76 in acetone. The lower jaws were removed from the

mount and packaged individually. The display base became the crate base by adding wood supports and replacing caster wheels. The right side of the frill was cut off through reconstructed materials using an oscillating saw. All specimen parts were padded with Ethafoam, then wrapped in plastic cling wrap and bubble wrap. Specimen pieces were secured to the deck of the display base for transport. Open space under the ventral surface of the cranium was infilled with wooden supports and expanding foam. Wood studs, diagonal braces, and plywood formed the crate walls and top. Campus Facilities staff used a forklift to take the crate off the museum's front steps, and transport it to a dedicated freight truck. All work processes were documented to aid in future work with the specimen at NMNH. Collaboration with CUMNH and Facilities staff minimized the project's impact to the museum and campus. Although onsite conditions required slight deviations from the original plans, advance planning proved essential to a successful project.

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

PRESERVED VERTEBRATE TRACKS IN PUSTULAR MICROBIAL MATS, LAKE POWELL SHORELINE: A MODERN ANALOG FOR THE MILL CANYON DINOSAUR TRACKSITE OF MOAB, UTAH

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The Lower Cretaceous Mill Canyon Dinosaur Track Site (MCDT) in Moab, Utah, developed in a lacustrine shoreline setting where pustular microbial mats facilitated in preservation of spectacular, diverse vertebrate ichnofossils. These ancient pustular mats represent microbially induced sedimentary structures that have been assigned the ichnotaxon *Pustularichnus rebeccahuntfosteriae*, but lack a documented modern analog from a lacustrine setting. Examination of microbial mats with vertebrate tracks on the Lake Powell (LP) shoreline provides a befitting modern analog that aids and strengthens the interpretation of MCDT.

Comparisons between the LP and MCDT sites can be made at various geomorphic and paleontologic scales. LP microbial mats developed at the lake margin during 2020 at or near the reservoir high stand. Pustular mats developed on the LP shoreline beach as water level rose to flood the delta top. A second type of mat, blister mat, grew at lower elevation during falling lake water level that formed a stranded isolated pond. Pustular mats at MCDT flourished on the shoreline setting of "Lake Carpenter." Both sites display preserved local topography that influenced the behaviors of vertebrate track makers. LP shoreline pustular mats are intensely trampled,

whereas lower elevation blister mats contain sparse traversing trackways that are eroding rapidly. Intense trampling is absent at the MCDT but traversing trackways are pervasive, supporting the LP observation that pustular mats preserve tracks better. LP has pervasive desiccation cracks and the absence of desiccation features at MCDT indicates the lack of extended exposure. Tracks at LP developed under moist sediment conditions with tracks truncating brittle to pliable mats, whereas those at MCDT are water saturated with tracks penetrating into sediment beneath flexible mats that were subjected to smearing and stretching. Due to falling water level, LP tracks developed over a limited time window and have since been subjected to continuous erosional modification. Tracks in MCDT show strong evidence of mat recovery ameliorating earlier tracks indicating the surface is not a short snapshot of time but a more prolonged stasis surface.

Funding Sources Kutztown University Research Committee

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

ECOLOGY OF EARLY THEROPOD FLYERS REFINED BY THEIR PEDAL ANATOMY

Pittman, Michael¹, Bell, Phil R.², Miller, Case V.³, Enriquez, Nathan J.², Wang, Xiaoli⁴, Zheng, Xiaoting⁵, Tsang, Leah R.⁸, Tse, Yuen Ting¹, Landes, Michael⁶, Kaye, Thomas G.⁷

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In modern birds, their feet are closely correlated to their ecology. Cursoriality, feeding mode and grasping ability are reflected in the toe pads, foot scales, joints and claws. To reveal the ecological characteristics shown by the feet of early theropod flyers, we present equivalent fossil evidence including soft tissues surrounding the foot bones. We interpret our foot-based results in the context of existing lines of evidence relating to the ecology of early theropod flyers (including their anatomy, diet and locomotor capabilities as well as the environments and climates they experienced). The earliest theropod flyers, including *Anchiornis* and *Archaeopteryx* from the Middle-Late Jurassic, had feet indicating a more ground-dwelling lifestyle. In the Early Cretaceous, the feet of early theropod flyers suggest that aerial lifestyles diversified. These lifestyles included generalists such as *Confuciusornis* and specialists such as the climbing

Fortunguavis. Some early birds like the Berlin *Archaeopteryx* and the Early Cretaceous *Sapeornis* had foot characteristics that suggest complex ecologies that were seemingly unique compared to modern birds. Surprisingly, the non-avian theropod flyer *Microraptor* was recovered with a more specialised raptorial lifestyle featuring hawk-like characteristics that were rare among theropod flyers of that time. This suggests that non-avian theropod flyers like *Microraptor* were specialists, similar to certain birds in modern ecosystems. Feet reveal tremendous ecological diversity in early theropod flyers.

Funding Sources Research Grant Council (HK) General Research Fund (17103315; 17120920; 17105221; to M.P.); HKU PG Scholarship (C.V.M.); Australian Government RTP Scholarship (N.J.E.)

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

A NEW NEOSUCHIAN CROCODYLIFORM FROM THE LOWER CRETACEOUS (ALBIAN-APTIAN) HOLLY CREEK FORMATION OF SOUTHWEST ARKANSAS AND ITS IMPLICATIONS ON THE RELATIONSHIPS OF NEOSUCHIA

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The Albian-Aptian Holly Creek Formation of southwest Arkansas contains a wide array of semiaquatic, aquatic, and terrestrial vertebrate body and trace fossils. Among them is a new crocodyliform, based on a nearly complete skull, with the potential to shed light on the properties and basal relationships within Neosuchia. The platyrostral skull is 53 cm long with a highly ornamented dorsal surface. Its overall morphology is similar to that of the putative goniopholidid *Denazinosuchus kirtlandicus* from the Campanian Kirtland Formation of New Mexico, though unlike *D. kirtlandicus*, the new form bears an anteromedially directed premaxilla-maxilla suture in palatal view. It shares certain features typically associated with goniopholidids, such as a transverse interorbital crest and perinarial crest. However, it also shares anterior and posterior rami of jugal comparable in depth, rod shaped jugal bar, and a frontal separated medially from orbit margin with paluxysuchids such as *Paluxysuchus* and *Deltasuchus*. This new specimen also bears an elongate anterolateral process of the postorbital (present in goniopholidids, paluxysuchids, pholidosaurids, and dyrosaurids).

Phylogenetic analyses including the new form support a close relationship with *D. kirtlandicus*, and the two forms fall out as basal paluxysuchids. The fate of relationships within a monophyletic Goniopholididae, a widespread Laurasian assemblage from the Jurassic through Cretaceous, varies among the optimal trees. The clade either forms distinct

groups correlated with spatial distribution or *Goniopholis simus* is found more closely related to *Amphicotylus* than other European goniopholidids.

These results challenge long-held assumptions about the status and distribution of Goniopholididae, which may have a more restrictive membership and spatiotemporal distribution than previously believed. They also bear on understanding morphological and ecophenotypic evolution on the line giving rise to extant crocodylians.

Funding Sources The University of Iowa Department of Earth and Environmental Sciences

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

A PARTIAL *DOLICHORHYNCHOPS OSBORNI* SKELETON (PLESIOSAURIA, POLYCOTYLIDAE) WITH ASSOCIATED STOMACH CONTENTS FROM THE PIERRE SHALE (LOWER CAMPANIAN) OF SOUTHWESTERN MANITOBA

Plouffe, Christian¹, Brink, Kirstin¹, Hatcher, Anita-Maria², Campbell, James³

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The Western Interior Seaway (WIS) was a large Late Cretaceous epeiric seaway that spanned from the Arctic Ocean in northern Canada to the Gulf of Mexico. Two biogeographical subdivisions have previously been identified within the WIS, characterized by distinct temperate zones and marine fauna: the cooler Northern Interior Sub-Province (NISP), and the warmer Southern Interior Sub-Province (SISP). The NISP was characterized by a distinctive group of predatory marine reptiles – plesiosaurs – which were rarer in the SISP. However, polycotylid plesiosaurs are not as well known in Canada as they are in the better-studied fauna of the southern portion of the NISP in the north-central USA. A better understanding of marine reptile diversity in the WIS will help in further reconstructing this unique marine ecosystem during the Late Cretaceous.

An osteologically mature polycotylid plesiosaur partial skeleton (CFDC P.04.01.15) with preserved stomach contents was collected from the Pembina Member of the Pierre Shale (early Campanian) in southwestern Manitoba in 2004. Bones were prepared for description and stomach contents were dissociated using a 10% solution of hydrogen peroxide.

Results show that the cervical vertebral count (N = 18) of this specimen is consistent with those of other polycotylids. The caudal vertebrae exhibit chevron facets borne by one vertebra, and the dentition is gracile with fine enamel ridges restricted to the upper two-thirds of the crown as in several

Dolichorhynchops species. The ilia are straight and blunt on the dorsal end. With a combination of these characteristics, this specimen can be referred to as *D. osborni*.

The microfossils within the stomach contents were analyzed establishing from a sample of 800 vertebrae, teeth, scales, and macerated fish remains. An unusual amount of 426 vertebrae were identified, alongside 243 scales and 126 teeth mostly belonging to teleost fish. The unusual number of vertebrae relative to scales and teeth is thought to be from the vertebra better withstanding digestion due to them being denser and larger. The stomach content analysis ultimately revealed that the last meal, and the animal's diet in general, were schools of teleost fish.

Funding Sources Funding was provided by an NSERC Discovery Grant to Dr. Kirstin Brink

Symposium: International Community Connections
(Wednesday, November 2, 2022, 1:45 PM)

EVOLUTION ACCEPTANCE AND COMFORT WITH EVOLUTION CONTENT AMONG KENYAN HIGH SCHOOL BIOLOGY TEACHERS

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In July 2018 and December 2019, we conducted one-day workshops focused on teaching evolution with a total of 35 high school biology teachers in Mogotio, Baringo County, Kenya. Here, we report pre- and post-workshop survey data collected from the teachers, who ranged from having 1-22 years of teaching experience. All respondents teach evolution in their classes; some teach the topic from a religious perspective, and most teach human evolution. Overall, the teachers were more comfortable teaching evolution of plants and animals vs. humans. Many teachers described teaching evolution as “challenging” but also “interesting”, and most reported facing concerns from students about learning evolution. Although all teachers except one described themselves as currently Christian, and nearly all answered a question about their views on the origin of life with a response involving a deity, they were more concerned about ways to reconcile students' uncertainty about the relationship between science and religion than reconciling their own uncertainty about this relationship - perhaps because many noted that they have faced religious or cultural concerns from students when teaching evolution. About half of the teachers directly addressed the relationship between science and religion in their classrooms in some way; some actively tried to help students reconcile these two ways of knowing the world, while others outlined the differences between them. Similar to published data on teachers in other countries, respondents reported being very interested in both stronger background knowledge about the science of evolution and in more

engaging teaching materials. At the beginning of the workshop, their average score on the MATE (Measure of the Acceptance of the Theory of Evolution), the most widely used evolution acceptance instrument, was 69 out of 80, categorized as “moderate acceptance”; this is lower than studies of science teachers from the US and Korea, but higher than a study of science teachers from Turkey. All teachers (100%) reported that the workshop increased their knowledge and comfort with teaching evolution. We plan to continue collaboration and professional development with these and other Kenyan teachers, including collecting information on their experiences with using the teaching resources presented in these workshops.

Funding Sources Project supported by European Society for Evolutionary Biology and Marshall University.

Virtual Posters

TAKING A STAB AT MODELLING THE BIOMECHANICS OF SABRE-TEETH

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Canine teeth are a key defining feature of predatory mammals and play a vital role in carnivore feeding ecology. The most impressive canines in nature belong to the ‘sabre-tooths’, an enigmatic group of extinct animals. With no living analogues, there has been much debate over the predatory behavior(s) of sabre-toothed taxa and how exactly their canines may have been used. Very few of these studies have focused solely on the tooth in question: the upper canines. In this study, we quantified the three-dimensional shape and biomechanics of sabre-tooth canines from taxa like *Smilodon*, *Homotherium*, *Barbourofelis*, and *Thylacosmilus* and placed them in a broad comparative context with living carnivores. First, to establish how canine shape varies, we measured a sample of 216 teeth representing 205 non-sabre and 11 sabre-tooth species using 3D geometric morphometrics (3DGM). Then, we assessed how shape variation impacted tooth stress via finite element analysis (FEA), with loading conditions applied to mimic a range of biting, pulling, and shaking behaviors. 3DGM shows that sabre-tooth canine forms are more slender than almost all living carnivores, with curvature that varies within the limits of extant species. Some sabre-tooth taxa, like *Smilodon*, *Barbourofelis*, and *Thylacosmilus* display a combination of curvature and slenderness not seen any living species. FEA simulations highlight the relative fragility of these extreme canine forms, which experience the highest stresses of all teeth

in simulated feeding behaviors. In addition, simulations help identify scenarios where extreme forms may be more likely break, for example, under shaking loads or during off-angle biting. To reduce canine tooth stress and likelihood of breakage, a sabre-toothed predator may bite into deformable parts of the prey like muscle, carefully place teeth to maintain an optimum contact angle, and limit lateral shaking loads. Taken together this combined approach offers new insights into the biomechanics of sabre-tooth canines and their functional capabilities.

Funding Sources Australian Government Research Training Stipend, Monash University Graduate Excellence Scholarship, and Monash University Department of Anatomy & Developmental Biology.

Technical Session - New Methods (Thursday, November 3, 2022, 10:15 AM)

SPATIAL PROCESSES, STATISTICAL MODELS, AND VERTEBRATE EVOLUTION IN A CHANGING ENVIRONMENT

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Evolution is a population-level process. Variation, drift, and selection components produce both temporal and spatial patterns of change. The patterns that emerge across space and through time can be fundamentally different than the expectation of statistical evolutionary models such as Brownian motion, stabilizing selection, and directional selection, even when the same process is involved. The disjunct between standard statistical evolutionary models and spatially explicit processes is that the standard models assume that the traits possessed by a species are homogeneous, each population giving rise to the next in what can be characterized as a “Fisherian” process after evolutionary statistician Ronald Fisher who was an early contributor to the statistics of natural selection. Spatial processes such as dispersal, gene flow, and geographic range changes, on the other hand, produce patterns of trait evolution that do not fit the expectations of Fisherian processes, even when evolution at the local-population level is governed by drift or a typical OU model of selection, and can be characterized as “Wrightian” after geneticist Sewell Wright who developed principles of genetic drift, structured populations, and adaptive landscapes. The evolutionary models that are widely used in palaeontology today incorporate the temporal component of these dynamics, but not the spatial. Using computational modelling, I show that range expansions and contractions introduce rate variability into Brownian motion processes, range expansions in a BM model can produce directional change, and spatial selection gradients can create spatial trait patterns that produce directional evolution and punctuation events depending on the balance between selection strength, gene flow, extirpation probability, and model of speciation. I also review evidence

that spatial patterning of morphology is common in vertebrates. The evolutionary outcomes of spatial processes therefore depart from the basic population-level notions that are embedded in standard macroevolutionary models and should be considered when inferring evolutionary rates and modes of evolution from phylogenetic or stratigraphically structured data.

Funding Sources This work was supported by US National Foundation Grant EAR-1338298 and the Yale Institute for Biospheric Studies.

Preparators' Poster Session

A COMPARATIVE INVESTIGATION OF ASPHALTIC FOSSIL PREPARATION FROM THREE BREA LOCALITIES: CALIFORNIA, ECUADOR & TRINIDAD

Potze, Stephany

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Through the BREAS Project (Bridging Research and Education at Asphaltic Sites), Rancho La Brea (RLB) aims to develop collaborations and share knowledge with paleontological contemporaries. Asphaltic fossil preparation is specialized, with <15 asphaltic paleontological deposits (breas) known worldwide. Several breas occur in South America and the Caribbean, such as Ecuador and Trinidad.

Quaternary ground sloth specimens (n=6) from RLB Project 23 Deposit 9 (P23-9), Ecuador's Tanque Loma (TL) and Trinidad's Forest Reserve (FR) locality were investigated to develop a comparative understanding of how different breas sediment types and preservational context impact fossil preparation. Studies at TL and FR suggest that asphalt was likely a secondary (post-depositional), rather than primary (RLB-style entrapment), taphonomic agent for these fossils, and matrix at these two localities have significantly higher clay content than RLB deposits.

Asphaltic fossil preparation requires targeted application of degreasing solvents to the adherent matrix, in order to soften and loosen the material for easy mechanical separation from the bone. We used Novec 73DE as the primary preparation solvent. Acetone was included as a solvent effective in removing high clay content matrix. We evaluated the effectiveness of these preparation materials and methods based on 1) the degree of surface removal of asphalt and matrix; 2) internal asphalt retention; 3) total preparation time; and 4) fossil integrity, which was monitored by tracking fossil conditions such as visible dehydration and cracking. Manual preparation with Novec 73DE proved effective for external asphalt removal from fossils associated with the three breas localities studied. Acetone worked well in liberating the high clay matrix from TL and FR material. Internal asphalt retention remains unaffected in all specimens. TL and FR specimens required more time and manual effort due to the

clay content in the matrix. The quantities of solvent and tools used appeared comparable between the sites. Fossil integrity remained stable throughout preparation with no visible dehydration or additional cracking.

Based on results of this preliminary investigation, Novec 73DE and manual techniques can be adopted as best practices for asphalt removal from RLB, TL and FR osteological specimens. Due to the secondary infiltration of asphalt at TL and FR, acetone is recommended as an additional step in removing the high clay residue.

Technical Session 4: Paleobiogeography (Wednesday, November 2, 2022, 1:45 PM)

PLEISTOCENE MARINE VERTEBRATES FROM SANTA CRUZ ISLAND AND THE TEMPO AND MODE OF ASSEMBLY OF THE QUATERNARY EASTERN NORTH PACIFIC MARINE FAUNA

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Despite their recency, Pleistocene marine vertebrates are relatively rare. The paucity of Quaternary sublittoral and shelf deposits is a major contributing factor to this knowledge gap. In the case of the Eastern Pacific, this gap occurs during the transition from Pliocene faunas to marine assemblages dominated by extant groups. A recently expanded collection of vertebrate fossils from the Middle Pleistocene of Santa Cruz Island (SCI) in the California Channel Islands contributes to ongoing efforts to understand this important period.

The fossils represent a fauna from the T2 marine terrace on the western end of SCI. The T2 represents a Middle Pleistocene highstand, with recent dates from lower and higher terraces suggesting an early Chibanian age, possibly MIS-17c (~700 ka). The skeletal assemblage includes shark, ray, teleost, sea birds (representing *Phalacrocorax*, *Sula*, *Chendytes*, and cf. *Mancalla*), postcranial elements from at least three otariid individuals, a lower canine (cf. *Mirounga*), a mysticete cervical vertebra (cf. *Eschrichtius*), and several bones and teeth of *Enhydra*, including a dentary with m1.

Even with the most conservative age estimates for T2, this material represents the oldest known adult dentition of *Enhydra*. The m1 has a large talonid, bicusped metaconid, and large shelf labiodistal to the hypolophid. In these and other features the robust SCI otter differs from extant *E. lutris* and extinct *E. macrodonta*, and may represent hitherto unrecognized diversity within the sea otter lineage. The otariid bones resemble *Arctocephalus* more than members of Otariinae, particularly in vertebral anatomy and phalanx proportions. A large otariine atlas confirms it is a multitaxic otariid assemblage, unknown from the Eastern Pacific before the Middle Pleistocene. The presence in southern California of an otariid with arctocephaline affinities suggests that this

diversity may have been quickly established following the loss of odobenid diversity around the Plio-Pleistocene boundary and provides potential data for understanding arctocephaline dispersal from the Southern Hemisphere.

More broadly, the mixture of extant mammalian genera and extinct avifauna may point to differential timing of turn-over between the two groups. Additional recovery and description of Pleistocene marine vertebrates will help to establish the speed and geographic pattern with which the dramatic Pliocene to Quaternary faunal turnover became established in the Eastern Pacific.

Technical Session 14: Squamates & Turtles (Friday, November 4, 2022, 1:45 PM)

TOOTH REPLACEMENT IN SNAKES: SYNAPOMORPHY OR CHAOS?

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Serpentes (snake-lizards) are the most diverse clade of lizards with nearly 4000 living species. Many species have highly kinetic maxillary, mandibular and palatal bones related to uniquely modified feeding styles associated with specializations for both large and small gapes. Many large-gape snakes possess highly recurved teeth that help hold prey, as well as slide their jaws over prey during food ingestion. The degree and consistency of tooth recurvature observed in snakes is not observed in other lizards and is considered a uniting feature of Serpentes. Early investigations of tooth replacement in snakes demonstrated they developed in soft tissue epithelia adjacent to the functional teeth and suggested that the crowns began development in an orientation parallel with the jawbones and changed in orientation as they moved to a functional position. Surveys of alcohol preserved, and dissected specimens corroborated this pattern. "Horizontal tooth replacement" became a synapomorphy of Serpentes in addition to tooth crown recurvature. Horizontal tooth replacement, however, was never quantified for statistical significance, nor observed in vivo. This creates uncertainty around the validity of the synapomorphy as it may be a consequence of both the tooth crown recurvature and postmortem effects on soft tissues housing replacement crowns. This has major implications for fossil taxa as taphonomy may create misleading conditions supporting

erroneous referral to major clades defined by untested primary homology statements. Using micro-CT scanners, thawed snake heads from frozen collections were scanned to examine their jaws and teeth. Representatives were selected from most major clades within Serpentes to incorporate any taxonomic variation. Functional and replacement crowns from each tooth family were segmented and their orientation to the jaw was measured. Crown angles were examined for any patterns and significant changes in tooth crown angles throughout development into an attached tooth. Patterns were compared across different jaw elements and between taxa for variation within individuals, and between species. In the absence of in vivo specimens, a pattern of tooth replacement is observed in which crowns begin development at near identical orientations to functional crowns, then proceed through a “horizontal” position late in development, prior to attachment. Crown angles show high variation between jaw elements and taxa.

Virtual Posters

AN ENDEMIC CURSORIAL STYRACOSTERNAN DINOSAUR FROM THE IBERO-ARMORICAN ISLAND OF THE LATEST CRETACEOUS EUROPEAN ARCHIPELAGO

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Ornithopod dinosaurs constitute one of the major radiations of Mesozoic vertebrates. These herbivores colonized every continent and left a rich fossil record spanning the middle Jurassic through the latest Cretaceous. One of the main evolutionary trends throughout ornithopod evolution is the progressive increase in body size and shift to mediportality. Here, we report on a relatively small styracosternan iguanodontian ornithopod from southwestern Europe, represented by a highly modified metatarsal IV nowhere to be found among ornithopods. The fossil comes from the Masía de Ramón locality, corresponding to uppermost Maastrichtian strata of the Talam Formation, Lleida province, NE Spain. Within Ornithopoda, this metatarsal IV is unique in combining the greatly elongated proportions of basal members of the clade with the prominent medial flange seen in more derived styracosternans such as hadrosaurids. Histological data indicates that this specimen was a late subadult at the time of death, approaching somatic maturity. By analogy with the elongate metatarsals of lightly built, small-bodied cursorial ornithopods, it is likely that this animal was also capable of rapid locomotion. This is consistent with the differential distribution of intense bone remodeling in metatarsal IV, likely resulting from biomechanical stress produced during rapid hindlimb propelling.

The Masía de Ramón styracosternan represents an exception to the subcursoriality and mediportality, as well as the relatively large body size, that characterize styracosternan dinosaurs, particularly members of Hadrosauriformes. The

elongation of metatarsal IV, inferred cursoriality, and small body size constitute a case of evolutionary convergence with the distantly related non-iguanodontian ornithopods and dryosaurid and elasmarian iguanodontians. This also suggests that the postcranial skeleton of these animals was capable of substantial morphological plasticity. Unlike other regions of the world where, during the latest stages of the Cretaceous, the small-bodied cursorial herbivore ecological niche was represented by non-iguanodontians and non-hadrosauriforms, in the Ibero-Armorican island this niche was likely occupied by a styracosternan. This animal represents a case of endemic small-bodied insular styracosternan with peculiar adaptations.

Funding Sources Grants RyC-2015-17388 and PID2020-119811GB-I00 funded by MCIN/AEI/10.13039/501100011033 and CERCA Programme funded by the Generalitat de Catalunya

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

THREE-DIMENSIONAL PRESERVATION AND VARIATION OF DREPANOSAURS (REPTILIA:ARCHOSAURIFORMES) FROM THE UPPER TRIASSIC HOMESTEAD SITE (TRIASSIC:REVUELTIAN:MID-NORIAN) OF EAST-CENTRAL NEW MEXICO, U.S.A.

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The Homestead site, an Upper Triassic locality near Garita Creek, New Mexico, has yielded a diverse assemblage of many thousands of microvertebrate fossils. Among the most recognizable elements are unguals and vertebrae of drepanosaurs, a bizarre group of diapsids hypothesized to be mostly arboreal and insectivorous. Drepanosaurs are currently known only from the Upper Triassic of the northern hemisphere, and the most complete specimens are known from slabs containing crushed skeletons preserved as essentially two dimensional objects. Whereas their unusual anatomy means isolated elements are easy to identify, it has left their life mode and phylogenetic relationships murky in spite of multiple known articulated skeletons. Drepanosaur fossils are rare (0.23%) at Homestead, but the locality thus far has yielded 35 isolated definite drepanosaur specimens, including six ‘caudal unguals’, 16 manual/pedal unguals representing at least four morphotypes, a distal end of a femur, and 12 vertebral fragments, all preserved in three dimensions. The ‘caudal unguals’ indicate at least six individuals are present in this assemblage, and two species appear to be present based on the two distinct large ungual morphotypes. The ‘caudal

unguals' and large manual unguals indicate that these are well-nested members within Drepanosauridae, similar to *Drepanosaurus*, although likely a distinct taxon. One morphotype of large manual ungual is similar to the laterally compressed unguals of *Drepanosaurus* and *Ancistronychus* in morphology, but differs from the former in having a flat ventral surface and lacks the strongly recurved spade-like distal portion of the latter. A second large ungual morphotype is relatively wide and flat, likely belonging to a taxon similar to the hypothesized burrower *Skybalonyx*. Curiously, both smaller ungual morphotypes possess flat ventral surfaces unlike any known drepanosaur. The first smaller morphotype is more laterally compressed with a large ventral tubercle, whereas the second is wider, flatter, and has a smaller tubercle, mirroring the larger ungual morphologies. Preservation of drepanosaur elements in 3D allowed us to generate a hypothetical model of how caudal vertebrae could have been modified to caudal unguals. Although it is difficult to reconstruct the Homestead drepanosaurs without articulated materials, one or more unnamed species may be present, and the unguals may suggest niche partitioning between a burrowing and an arboreal species.

Funding Sources The National Science Foundation, the Appalachian State University GES Department and Office of Student Research, and the Lauer Foundation for Paleontology.

Technical Session 16: Hoofed Mammals (Saturday, November 5, 2022, 8:00 AM)

NEW PHYLOGENY OF LITOPTERNA AND “ARCHAIC” PALEOGENE UNGULATES ENLIGHTENS THE INTERFAMILIAR AFFINITIES WITHIN THE ORDER

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South American Ungulates (SANUs) exhibit astonishing morphological and ecological diversity due to their almost complete isolation during their early evolution. This unique diversity coupled with the limited fossil record of their earliest evolution makes it difficult to establish their phylogenetic position within the placental mammal tree. Litopterna is the second most diverse order of SANUs after only Notoungulata, with species ranging from the middle Paleocene (~63 Ma) to the late Pleistocene. Among SANUs, litopterns are characterized by having cursorial limbs similar to Holarctic groups like Perissodactyla. Currently there are 67 genera of litopterns grouped into nine families, and the affinities of the Paleogene families remain unclear. Furthermore, it is unclear

how litopterns are related to older groups of “archaic” Paleogene ungulates of South America (Kollpaninae and Didolodontidae) and North America (e.g., Mioclaenidae), and other SANUs.

To test the phylogenetic relationships of Litopterna, we assembled a new morphological matrix with ~1000 craniodental and postcranial characters for 79 taxa. The data were subjected to Bayesian and maximum parsimony analyses. We conducted tip-dated and undated Bayesian analyses using a Mk + Γ model of morphological evolution. Fifty percent majority rule consensus trees were obtained from the sampled trees from each analysis. The parsimony analysis resulted in ten most parsimonious trees and a strict consensus was computed. The consensus trees derived from the different analyses were largely congruent. A traditional monophyletic Litopterna failed to be recovered as Protolipternidae was closely related to Didolodontidae. Litopterna was found more closely related to Kollpaninae than to North American Mioclaenidae, and Kollpaninae did not form a monophyletic group with the latter. Adianthidae and Indaleciidae were found in a relatively basal position within Litopterna. Macrauchenidae was found as a sister group to Protheroheriidae, whereas Anisolambdidae was the sister group of Sparnotheriodontidae, these four families forming a monophyletic group. By utilizing a more comprehensive approach, these results alter previous conceptions of the intrafamilial affinities within Litopterna and their position among other Paleogene ungulates, shedding new light on how litopterns evolved and diversified during the Paleogene of South America.

Funding Sources ANID-PFCHA-Doctorado en el extranjero Becas Chile-2018-72190003, ERC starting grant PaLM 756226, NSF DEB 1654949 and 1654952

Technical Session 10: Soft Tissues & Taphonomy (Friday, November 4, 2022, 8:00 AM)

SCRAMBLED EGGS: SYNCHROTRON SCANS OF EGGS FROM THE EARLIEST JURASSIC SEEM TO REVEAL UNUSUAL TRAITS IN EARLY DINOSAUR EMBRYOS

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Using synchrotron propagation phase-contrast microtomography on the BM05 beamline of the ESRF-EBS, we analyzed the contents of four Hettangian eggs from a dinosaur nesting site in Poland. The scans revealed that all four eggs, which were collected from the same nest structure, contain embryonic remains. The preservation of the bones indicates a complex taphonomical history involving both

abiotic and biotic factors (e.g. invertebrate scavenging). The embryos are highly disarticulated, and most bones are broken, shattered, or missing. However, other bones are well preserved, and scales, skin impressions and mineralized soft tissues are present in some eggs. The incompleteness of the skeletons makes identification of the embryos difficult, but a theropod affinity of the embryos is suggested based on eggshell microstructure, the presence of blade-like serrated teeth, and a few cranial and postcranial skeletal features. The embryos died at a late developmental stage, which is indicated by ossification of cranial elements, fusion of the centrum with the neural arch in distal caudal vertebrae, and by the eruption of teeth. Interestingly, the embryos possessed osteoderm-like epidermal structures, which is highly unusual for theropods, and a palatal dentition, which contrasts with the condition seen in most archosaurs. We postulate that palatal dentition might have been a more widespread trait among juvenile dinosaurs than previously known, and retention of palatal teeth in other saurischian genera is likely the result of paedomorphism. The analysis of dinosaur embryos using propagation phase-contract microtomography enables the extraction of valuable data even on highly disarticulated and incomplete embryonic material, here exemplified by the study of the oldest probable theropod embryos to date.

Funding Sources We acknowledge the ESRF (proposal LS-2973) for beamtime access on the beamline BM05. MQ is funded by a grant from the Swedish Research Council (grant no. 2020-06445).

Colbert Prize Session

MACROEVOLUTION OF THE ORNITHISCHIAN DENTAL BATTERY

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The ability to process and digest plant matter has independently evolved countless times among vertebrates. The constraints herbivory places on organisms often necessitates a stereotypical cascade of analogous bauplan modifications between even distantly related groups. While their origins were humble, serving as small but cosmopolitan constituents of Jurassic ecosystems, ornithischian dinosaurs would eventually become the most conspicuous, speciose, and diverse large-bodied herbivores by the Late Cretaceous. Elaborating on the plesiomorphic condition, two ornithischian lineages, Ornithopoda and Ceratopsia, both independently evolved dental batteries. Dental batteries, generally characterised as mosaics of multiple tooth families uniformly worn to produce a single triturating surface, have previously attracted research interest. The ultrastructural refinement of individual teeth of specific derived taxa has been studied, as have rates of evolution of dental characters. However, we still lack deeper insights into the macroevolutionary drivers behind

the evolution and refinement of dental batteries. We ameliorate this by devising a novel method quantifying a suite of orodontal proxies sampled from species spanning derived and early-diverging members of ornithopods and ceratopsians. Ornithischian dentitions require direct wear to function, so our new method co-opts aspects of the qualitative mesowear and microwear analyses typically used in mammalian systems into a quantitative method appropriate for studying herbivorous, polyphyodont dinosaurs. Using a combination of μ CT and laser surface scan data, we quantify the volume of worn dental material as well as the surface areas of the resultant triturating surface in the dentary and maxillary tooththrows. These metrics can then be scaled against relevant measures of skull and body size as well as biodiversity, to investigate the macroevolutionary implications of dental battery evolution. We present preliminary results of this method that elucidate the trade-offs involved in individual tooth size, dental battery surface area, masticatory efficiency, and ornithischian diversity and distribution patterns.

Funding Sources National Science Foundation FRES 1925884

Preparators' Session (Thursday, November 3, 2022, 8:00 AM)

VIRTUAL RECONSTRUCTION OF THE PARANASAL SINUS AND NASAL AIRWAYS OF THE GIBRALTAR-1 *HOMO NEANDERTHALENSIS* SKULL.

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This work exposes new methods of virtual reconstruction, which in combination, provide an emerging potential for solving fossil record problems, in this case study, the skull of the Gibraltar-1 specimen, *Homo neanderthalensis*. Fossil remains of Neanderthals rarely preserve details of internal anatomy such as the endocranial base or internal facial structures. Gibraltar 1 lacks a considerable part of the neurocranium, yet the internal part of the nasal region is comparatively well preserved. Thus, in the context of paleophysiological related research there is a great need for improved virtual reconstruction methods. Such methods must be non-invasive given the importance of the material; therefore, we start from image acquisition techniques such as computed tomography. Once these image data are obtained, a virtual reconstruction processes can be carried out. First, by using various specialized image enhancement programs, we improve image quality and eliminate artifacts due to taphonomic materials of the fossil. Then, based on comparative material of morphologically, phylogenetically, or

otherwise related specimens and human cranial material, we proceeded to the virtual generation of missing anatomical regions of the fossil. For this purpose, we used techniques of anatomical repositioning, mirroring, and positional calibration. For a better control of the thickness, shape and position of the generated bone elements, topological deviation techniques and distance analysis thickness were applied. The result of this virtual reconstruction provides great anatomical detail and information. Particularly, our reconstruction offers a highly detailed and complex endocast of the paranasal sinus and more information on internal anatomical elements of the nasal region and airways. Based on this newly reconstructed bone information, further improvement was achieved using 3D (semi-)landmarks for quantitative, geometric morphometric tissue reconstruction by missing landmarks estimations. This new reconstruction of the soft-tissue airways suggests a relatively high nasopharynx, narrow air passages and vertically oriented choanae. These new mesh configurations gave us new results in the CFD simulations in Flowgy, giving an improvement in the middle and final part of the nasopharyngeal path in air acclimatization and a lower nasopharyngeal pressure. These data indicate that further high-precision reconstruction is needed to decipher fossil physiology using modern technology.

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Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

THE BRAIN ARCHITECTURE OF *MIRACINONYX TRUMANI*

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The living cheetah (*Acinonyx jubatus*) is an atypical member of the felid family (Felidae) that reaches speeds of up to 25.9-29 ms⁻¹ in a 500m reaching top accelerations in 3 seconds. However, members of the extinct genus *Miracinonyx* convergently evolved anatomically-specialized traits for fast-running to pursue prey across the Pleistocene North American savannahs. Indeed, although *Miracinonyx* is more related to the cougar (*Puma concolor*) than to living *Acinonyx*, both taxa possess a highly-specialized skeleton for fast-running, including a shortened face, an expanded nasal cavity for increased oxygen consumption, long and lightly-built legs and a highly flexible lumbar spine and tail. Despite this remarkable convergence, no prior study has compared the brain architecture of *Miracinonyx* relative to that of *Acinonyx*.

Our results demonstrate that the brain of *Miracinonyx* is more *Puma*-like than *Acinonyx*-like but some traits are convergent with its living Old World vicar.

Funding Sources Acknowledgment of funding sources
ID project: UMA18-FEDERJA-188

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

THREE-DIMENSIONAL ANATOMY OF DERIVED SOUTH AMERICAN CYNODONTS AND HOMOPLASY IN THE EVOLUTION OF THE MAMMALIAN JAW JOINT

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The acquisition of the mammalian jaw joint and middle ear was a key event in synapsid evolution. Previous research has described morphological changes to the jaw joint and postdentary bones across the cynodont/mammaliaform transition, but more recently discovered non-mammaliaform probainognathian cynodonts from South America have thus far not been integrated into comparative anatomical studies, despite being represented by numerous specimens including ontogenetic series. In this study, micro-CT data from nine specimens of *Brasilodon quadrangularis*, the sister taxon to mammaliaforms, and ten specimens of *Riograndia guaibensis* were segmented to produce an updated description of the jaw articulations of these taxa in three dimensions for the first time. Our findings indicate that the jaw joint of *Brasilodon* has more plesiomorphic traits than in previous interpretations, lacking a clear squamosal-dentary contact/articulation and instead relying on a main quadrate-articular joint. By contrast, *Riograndia* possesses a more developed squamosal-dentary contact to reinforce the plesiomorphic jaw joint, formed by a robust postdentary bone complex. These findings suggest that the dentary-squamosal jaw joint evolved convergently in separate cynodont lineages, and that the cynodont/mammaliaform transition was characterised by homoplasy, similarly to the independent acquisition of the definitive mammalian jaw joint and middle ear in Mesozoic mammals.

Funding Sources This work is part of a BBSRC PhD project organised through the SWBio DTP titled "Development, function and evolution of the mammalian jaw joint and middle ear"

THE POWER OF COLLABORATION: IMPROVING COMMUNICATION AND OUTREACH WITH INDUSTRY STAKEHOLDERS TO IMPROVE FOSSIL RECOVERY FROM AREAS IMPACTED BY URBAN DEVELOPMENT IN ALBERTA, CANADA

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The Province of Alberta has well-established regulations for the survey of fossiliferous areas and the collection of fossils. Fossil resources are protected under the Historical Resources Act. Because the largest urban centres of Alberta are located atop fossiliferous rock formations, developments in these areas are often required to include a palaeontological monitoring program to maximize the recovery of fossil specimens during activities that directly impact these deposits.

Many industry stakeholders remain hesitant about these procedures resulting in deadline delays or capital loss, mainly due to a lack of understanding of what local fossils look like, what is involved in collecting them, and what positive impacts on local interest and tourism they have. Although there is ample availability of outreach and educational programs focused on the public that already has an active interest in fossils or an educational background that strongly overlaps with palaeontology, few of these programs are focused on adults with an industry or construction background or on the interaction between industry and preservation of Alberta's fossil resources.

Because on-site operators have a privileged view of fossiliferous rock exposures for several hours a day, it is proposed that if some time is invested in their education about the local fossils expected to be encountered in their work sites, the rate of recovery of these fossils during construction will increase. When comparing projects of similar magnitude within rock deposits of the same formations over the last five years, an increase in fossil recovery was observed during projects that included an initial educational session of on-site staff (through presentations often including local fossil specimens), and the ones which did not. Within the Paleocene Porcupine Hills Formation, the rate of recovery of fossils per hour of fieldwork increased from 0.4 to 0.8. Within the Quaternary Empress Formation, the rate increased from 0.1 to 0.4. Within the Cretaceous Horseshoe Canyon Formation, the rate of fossil recovery increased the most, from 0.02 to 0.15. This significant increase in recovery rates suggests that the time invested on education and outreach has excellent potential to increase fossil recovery and preservation of specimens for future research. It is proposed that educational programs of on-site staff become a standard and required practice for large scale developments to maximize fossil recovery.

Funding Sources Lifeways of Canada Limited

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

THE EVOLUTION AND PHYLOGENY OF EARLY TELLURAVES (“LANDBIRDS”)

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Telluraves are a clade of birds defined by their arboreality and contains the most species-rich avian group, the passerines. Although recent phylogenomic analyses have clarified the interrelationships among crown-group birds, the results of these studies show notable incongruities with each other and with morphology-based hypotheses. Despite a relatively intensive research focus on extant birds, there are still many questions relating to their early evolutionary history, particularly the affinities of extinct fossil groups with distinct ecomorphologies, their implications for the evolution of ecological traits, and the extent to which morphological character states support key nodes in the molecular phylogeny of Telluraves. Over the last 20 years, fossil discoveries and molecular clock analyses have provided strong evidence that the earliest known stem-group representatives of many extant avian orders appeared in the Paleogene, a crucial time period for understanding the history of diversification of birds. Despite the fossil record being well represented and abundant, the identities of many specimens and the affinities of these species, in general, remain controversial and poorly understood, particularly for less complete remains. We are in the process of creating a new phylogenetic analysis of early Telluraves. So far, a character list of 450 characters has been assembled based on a review of key phylogenetic studies on stem- and early crown-group Telluraves and was augmented by new characters based on personal examination of 60 extant and 58 fossil taxa. This work will ultimately resolve several phylogenetic issues that currently lack consensus amongst higher taxonomic groups. Furthermore, combining morphological and molecular data in the phylogeny will be used to quantify the rates of evolutionary changes in the clade.

Funding Sources NERC DTP University of Oxford and Claredon Fund Scholarship

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

DATA FROM EXTANT TETRAPODS HIGHLIGHT THE POTENTIAL FOR TRABECULAR BONE ARCHITECTURE AS A PROXY FOR POSTURE AND LOCOMOTOR ECOLOGY IN EXTINCT TAXA

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Trabecular bone is a porous bone tissue formed by small struts nestled within the external cortical shell of most elements. Trabeculae are optimized to strengthen the bone with minimal additional mass. Although Wolff's Law proposes that both trabecular and cortical architecture are determined by external stresses, trabeculae can remodel five to ten times faster than cortical bone. Therefore, trabeculae present a more malleable record of the effect loading strain has on bone. Previous research has measured the variability in trabecular characteristics present in humans and several model species, but there has been little work done to quantify the variation present across a wide range of extant and extinct Tetrapoda. Understanding the trabecular architecture of fossil taxa has the potential to provide unique insights into reconstructing limb posture and function that cortical bone or range-of-motion analysis alone cannot provide. Proper investigation into extinct clades will require a robust dataset of extant taxa with diverse locomotor ecologies to serve as the basis for such predictions.

Here, we sample the trabeculae of fifty-five extant species of terrestrial Mammalia and non-avian reptiles. Species were selected to sample the range of body mass, ecomorphotypes and general postural grades exhibited by both clades. Trabeculae were sampled from the proximal articular head of both the humerus and femur, with each aligned in a uniform orientation regardless of how the bone is held in life. Five characteristics were measured for each trabecular structure: anisotropy, bone volume, trabecular thickness, trabecular number, and primary orientation. Initial results suggest that the greatest variation in trabecular bone architecture is associated with differences in locomotor ecology. For example, arboreal and generalist groups feature the highest variation in anisotropy between species, whereas semi-aquatic and cursorial species feature large variation in both trabecular thickness and density. Our results suggest trabecular bone architecture has potential as a proxy for locomotor ecology and posture in extinct taxa. Following additional validation with a larger sample of extant taxa, we plan to analyze the trabecular bone architecture of extinct synapsids whose posture and locomotion have been the subject of controversy.

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

NEW SAUROPODOMORPH MATERIAL FROM THE EARLY TO MIDDLE JURASSIC OF MOROCCO AND INSIGHTS ON PREVIOUSLY DESCRIBED CERVICAL VERTEBRAE FROM THE HAUTE MOULOUYA BASIN

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The Jurassic sauropod fossil record of Morocco is rich in tracks and bones, but comparatively few specimens have been described in detail yet. It includes the brachiosaurid *Atlasaurus imelakei* and the material originally described as '*Cetiosaurus*' *mogrebiensis* from the late Middle Jurassic and the vulcanodontid *Tazoudasaurus naimi* from the late Early Jurassic. Recently, a further specimen composed of two middle cervicals (NHMUK PV R36834) was described, from supposedly early Early Jurassic rocks. It was collected from the Haute Moulouya Basin, a region located between the High and Middle Atlas in central Morocco. Here we describe and analyze the fossil SNSB-BSPG 2014 I 106, composed of four articulated middle to posterior dorsal vertebrae. This fossil was found in the same locality as the cervical vertebrae, and thus probably belongs to the same individual. The exact location places the material within a massive marine unit related to the global transgression at the Sinemurian-Pliensbachian boundary. Satellite information systems corroborates its placement within the marine unit and rather high in the tidal sequence. This means that the material is actually younger than previously proposed, at least late Early Jurassic. Previous phylogenies have placed NHMUK PV R36834 at a basal position within Eusauropoda, thus representing the earliest record of this clade. Preliminary phylogenetic results show that by adding SNSB-BSPG 2014 I 106, NHMUK PV R36834 is pushed to a position adjacent to Sauropoda (syn. Gravisauria), in a clade together with *Amygdalon patagonicus* and *Gongxianosaurus shibeiensis*, while SNSB-BSPG 2014 I 106 is recovered within or next to a clade containing *Sanpasaurus yaoui* and vulcanodontids. When both fossils are merged in the phylogeny, the position of the specimen is within the clade formed by *Amygdalon patagonicus* and *Gongxianosaurus shibeiensis* near Sauropoda. Thus, SNSB-BSPG 2014 I 106 provides new information on the position and age of NHMUK PV R36834, and together these remains probably represent a new taxon.

Funding Sources Lehre@LMU Student Research Award

Romer Prize Session (Thursday, November 3, 2022, 8:00 AM)

SMILODON FATALIS WAS SEXUALLY DIMORPHIC AND SOCIAL, AS REVEALED BY OSTEOHISTOLOGY

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Life history is a fundamental aspect of an organism's biology that is correlated with other ecological traits and extinction risk. Life history can be studied in the fossil record using osteohistology, but established mathematical methods for

growth curve reconstruction have not been adequately tested and applied in fossil mammals. This study tested the viability of these growth curve reconstruction methods on extant felids and applied them to document growth in the saber-toothed cat *Smilodon fatalis*. Results were used to test two controversial hypotheses: (1) *S. fatalis* was not strongly sexually size dimorphic, and (2) *S. fatalis* was social.

Observational and osteohistological growth data were collected from lions (*Panthera leo*), tigers (*P. tigris*), and *S. fatalis*. Osteohistology of *P. leo* and *P. tigris* femora indicate that lines of arrested growth (LAGs) can be reliably used to infer growth and life history. Growth curves for observational and histological data were created, best-fit models were determined using AIC, and their parameters were compared. Extant felid growth curves capture observed patterns of growth, detect male-biased sexual size dimorphism in adult body mass (sexual dimorphism ratio = 1.55, *P. leo*; 1.56, *P. tigris*), and show that maximum daily growth rate (kg/day) is negatively associated with sociality.

Growth models based on osteohistology from 20 *Smilodon* femora indicate it reached adult body size in 5 years, with a maximum daily growth rate of 0.2-0.5 kg/day. There is >100 kg variation in the estimated adult body mass of *S. fatalis*, supporting the hypothesis that these cats were similarly size dimorphic as extant felids. Maximum daily growth rates in *S. fatalis* are low and are more like *P. leo* than *P. tigris*. Slow maturation is consistent with gregarious social behaviour in the sabre-toothed cat, as predicted by life history theory.

This study represents the first rigorous modelling of growth curves in a fossil mammal and highlights the utility of such studies for inferring paleoecology. Results suggest that *S. fatalis* was a slow growing, sexually dimorphic, and social species. Low growth rates are known to correlate with increased extinction risk in extant animals and slow life history may have played a significant role in the end-Pleistocene extinction of *S. fatalis*. The methods used here provide a novel framework for understanding extinct mammalian ecology and will provide new insights into their evolutionary ecology.

Funding Sources Ontario Graduate Scholarship; NSERC Discovery Grant to David Evans (RGPIN-2018-06788)

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

A NEW SPECIES OF ACMEODON (MAMMALIA, CIMOLESTIDAE) FROM THE EARLY TIFFANIAN (LATE PALEOCENE) OF THE BISON BASIN, WYOMING, USA

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Acmeodon is a genus of insectivorous eutherian mammals documented from various Torrejonian and early Tiffanian faunas across the Rocky Mountain West (Montana, Wyoming, Utah, and New Mexico). Two species have been named, including the genotype *Acmeodon secans* Matthew and Granger, 1921 (holotype from Torreón Arroyo in the San Juan Basin, NM) and *A. hyoni* Rigby, 1980 (holotype from Swain Quarry, Carbon County, WY). *A. hyoni* is often considered a junior synonym of *A. secans*. *Acmeodon* was originally classified as a leptictid and was later assigned to either Palaeoryctidae or Cimolestidae. Multiple field seasons at the Saddle locality in the Bison Basin of central Wyoming have led to the discovery of a new and younger species of *Acmeodon* from the early Tiffanian (Ti2; ~60.5 Ma). In contrast to *A. secans* from the San Juan Basin, the new species from the Bison Basin has only two lower premolars with a short diastema between C₁ and P₃. In the Bison Basin species P₄ is larger and morphologically derived with respect to the condition in *A. secans*. Mesially, P₄ in the Bison Basin species bears a trenchant preprotocristid with no development of a paraconid, whereas the distal part of the P₄ trigonid bears similarly sized and transversely arranged metaconid and protostylid embracing a deep fissure on the postvallid. The P₄ talonid is broader than in *A. secans*, with distinct hypoconid, hypoconulid and entoconid cusps. P₄ in the Bison Basin species is relatively square in occlusal outline and bears an expanded parastyle, an expansive trigon, and a raised lingual crest (postprotocingulum). Heavy apical wear on major cusps indicates a diet focused on hard objects, possibly molluscs. This new species highlights the autapomorphic nature of *Acmeodon* with respect to closely related taxa such as *Gelastops*. The Bison Basin species will also provide an enhanced understanding of dental and dietary changes through time in this taxon.

Funding Sources This research was partly supported by an REU supplement to NSF 1543684 and the David B. Jones Foundation. Fieldwork was facilitated by BLM permit PA15-WY-234.

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

DIVERSIFICATION OF THE RUMINANT SKULL ALONG AN EVOLUTIONARY LINE OF LEAST RESISTANCE

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Morphological integration is a fundamental concept in evolutionary biology and paleontology because the structure of variation within populations determines the ways in which those populations can respond to selective pressures. However, understanding the macroevolutionary consequences

of morphological integration is elusive because the adaptive landscape is dynamic and population-level constraints themselves evolve. By analyzing a previously published dataset of 2857 ruminant crania with 3D geometric morphometrics and phylogenetic comparative methods, we find that variation within and between ruminant species is strongly biased by a highly conserved mammalian-wide allometric pattern, CREA, where larger species have proportionally longer faces. We find that more integrated species explore greater ranges and volumes of morphospace, and Ruminantia as a clade diversifies farther than expected given a Brownian motion model of evolution, but only in directions anticipated by CREA. Our analyses indicate that CREA is acting as an evolutionary 'line of least resistance' and is facilitating morphological diversification because it is aligned with ecological selective pressures associated with the browser-grazer continuum. These findings demonstrate that biological processes constraining variation at the microevolutionary level can produce highly directional phenotypic evolution over macroevolutionary timescales and provides an empirical example of morphological integration acting as a facilitator of, rather than an impediment to, morphological diversification.

Funding Sources National Science Foundation Graduate Research Fellowship

Technical Session 20: Crocodylomorpha (Saturday, November 5, 2022, 1:45 PM)

CROCODYLIAN PREY EXCLUSIVITY AND THREE NEW ALLIGATOR SPECIES FROM THE MID TO LATE MIOCENE OF FLORIDA: INSIGHTS FROM GEOCHEMICAL DATA AND HIGH-RESOLUTION CT SCANS

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Alligator is a charismatic genus of crocodylian with two extant species restricted to North America (*Alligator mississippiensis*) and east Asia (*A. sinensis*). The origin of this genus can be traced to the late Eocene-early Oligocene of midwest North America (NA), with subsequent eastward displacement into Florida around 18 Ma. Hitherto, six recognized species are known from the fossil record, however their relationships within the genus and the assignment of fossils to these species remains difficult to assess. This uncertainty can often be attributed to both geographic and temporal gaps in the published literature, a gap not reflected in the fossil record, where alligator fossils are commonly recovered across the Southeastern United States. Utilizing the collection housed at the Florida Museum of Natural History, we performed a comprehensive review of alligators from

Florida over the past 18 Ma to address this gap in our understanding of the evolutionary history of alligators. For this study, cranial elements were used exclusively because of their taxonomic usefulness. 17 sites were identified as producing alligator fossils, and over 100 elements, including complete skulls, were included in this research. Thomas Farm (~18 Ma) and Montbrook (~5.5 Ma) represent our largest and best-preserved sites, producing several complete, three-dimensional skulls. To study the morphology of these skulls, high-resolution CT scanners and 3D laser scanners were used to generate digital 3D models of the fossils, as well as skulls from all other modern Crocodylian genera. We utilized three-dimensional geometric morphometrics and Principal Component Analysis to measure shape change in each taxa. Additional matrix-based cladistics (Brochu, 2011) was performed. Lastly, to address the paleoecology of these alligator populations, enamel stable isotope geochemistry data was collected from all fossil alligator sites, and from contemporaneous *Thecachampsa* populations. Dietary data was assessed from $\delta^{13}\text{C}$ ratios, and water salinity was assessed from $\delta^{18}\text{O}$ ratios.

Results from these efforts produced the identification of three new fossil alligator species from Florida and a taxonomic reevaluation of a fourth. Results from isotopic analysis of crocodylian and alligator fossil teeth suggest prey exclusivity between the two groups until the extirpation of crocodiles from Florida. Additionally, our analyses of the CT scans revealed a novel cranial bone not documented within Crocodylia.

Virtual Posters

INSIDE THE HEAD OF ONE OF THE SMALLEST CROCODYLIANS: PALEOECOLOGICAL INSIGHTS FROM THE NEUROMORPHOLOGY OF *TRILOPHOSUCHUS RACKHAMI*, AND TRACING THE ORIGINS OF MEKOSUCHINAE

Ristevski, Jorgo

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Since its establishment in 1993, the now extinct crocodylian clade Mekosuchinae has been regarded as a subset of Crocodylidae that was endemic to Australasia (Australia and some South Pacific islands). Certain mekosuchines are also thought to have occupied more varied ecological niches than most extant taxa, pointing to an underappreciated role of crocodylians in Australian paleoenvironments. To better understand the paleoecology and phylogeny of mekosuchines, the anatomy of one of the smallest (<1 m in total length) and most morphologically distinct members of the clade, *Trilophosuchus rackhami*, was studied in detail. The holotype of the middle Miocene mekosuchine *T. rackhami* is one of the best-preserved crocodylian fossil specimens ever found in Australia. Micro-CT scanning of its exceptionally preserved cranium has allowed for an

unprecedented understanding of mekosuchine braincase anatomy and the most in-depth paleoneurological study for an extinct Australian crocodylomorph yet. The peculiar neuromorphology of *T. rackhami* offers relevant insights that may help elucidate aspects of the taxon's paleoecology. Although the overall morphology of the brain endocast is unique to *T. rackhami*, it also shares remarkable similarities with the terrestrial notosuchians *Araripesuchus wegneri* and *Sebecus icaeorhinus*. In addition, the inner ear of *T. rackhami* has an unusually tall common crus with one of the greatest height ratios among crocodylomorphs with known endosseous labyrinths, which is akin to some basal crocodylomorphs, basal crocodyliforms, and few notosuchians. The paratympenic pneumatic system of *T. rackhami* is greatly developed and most similar to the two extant crocodylians with notable terrestrial tendencies, *Osteolaemus tetraspis* and *Paleosuchus palpebrosus*. Thus, the unique combination of cranial and neuroanatomical features hints toward a more terrestrial paleoecology for *T. rackhami* than that of extant crocodylians.

Phylogenetic evaluation reaffirms the placement of *Trilophosuchus* as a member of Mekosuchinae, and almost all analyses consistently recovered a monophyletic Mekosuchinae that is part of the larger crocodylian clade Longirostres. However, the traditional assignment of Mekosuchinae as a subfamily of Crocodylidae is not supported. Moreover, potential mekosuchine affinities with the Late Cretaceous–Paleogene orientalosuchins from southeast Asia are proposed, suggesting the possible presence of Mekosuchinae outside of Australasia.

Funding Sources Funding was provided by a University of Queensland International Postgraduate Scholarship granted to Jorgo Ristevski.

Technical Session 17: Fish (Saturday, November 5, 2022, 8:00 AM)

DIVERSIFICATION OF JAW GEOMETRY DURING THE INITIAL RADIATION OF LOBE-FINNED FISHES (OSTEICHTHYES: SARCOPTERYGII)

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The origin of crown sarcopterygians around 420 Ma precedes the emergence of major lineage specializations, including contrasts relating to morphology of the feeding apparatus. Key examples include dental plates in lungfishes, reduction of marginal jaw bones in coelacanth, and elaboration of fangs in a variety of porolepiforms and tetrapodomorphs. Such putative ecological divergence, alongside evidence that individual lineages showed high rates of evolutionary change early in

their history, mark this event as a possible episode of adaptive radiation. Here, we explicitly test the adaptive radiation hypothesis using mandibles as a taphonomically robust, taxonomically diagnostic trait that is intimately associated with ecology. We assembled a dataset of 30 three-dimensionally preserved jaws of total-group Sarcopterygii obtained by CT scanning or photogrammetry. Most are dipnomorphs or tetrapodomorph fishes, plus a smaller sample of stem sarcopterygians and taxa of less certain placement. We developed a basic landmarking scheme (6 fixed landmarks, 8 curves with sliding semilandmarks) capturing overall jaw shape and orientation, including aspects of the glenoid and adductor fossa. We paired these shape data with a composite phylogenetic tree with branch durations informed by the ages of fossil tips. We examined the fit of three basic models of trait evolution to these shape data in a multivariate framework: Brownian motion (BM; diffusive evolution at a constant rate), early burst (EB; diffusive evolution with a declining rate over time, corresponding to theoretical predictions for adaptive radiation), and Ornstein-Uhlenbeck (OU; constant rates of change with a central tendency limiting the accumulation of variation over time). Our results indicate that EB is the best-supported model for describing the early evolution of lobe-finned fish jaw shape, corroborating our hypothesis. This implies that high initial rates of phenotypic evolution complemented the extensive exploration of shape space early in the history of the group.

Funding Sources University of Michigan (U-M) Rackham Merit Fellowship, U-M Department of Earth and Environmental Sciences Turner Grant

Romer Prize Session (Thursday, November 3, 2022, 8:00 AM)

THE ECOLOGICAL, MORPHOLOGICAL, AND DEVELOPMENTAL DRIVERS OF AXIAL SKELETON EVOLUTION IN REPTILIA: RECOVERING HISTORIES OF SKELETAL COMPLEXITY IN THE MOST DIVERSE TETRAPOD CLADE

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Traditional hypotheses on axial skeleton evolution suggest a linear increase in anatomical complexity from morphologically homogeneous, poorly regionalized fish to heterogeneous, highly regionalized mammals, with moderate complexity assumed in non-mammalian tetrapods such as reptiles despite highly varied body forms and ecologies across the clade. Higher than expected degrees of regionalization have been reported in limited samples of squamates and crocodylians, but axial skeletal regionalization has never been examined across the total clade, and no previous study has explored the relationship between axial skeletal diversity and ecology in reptiles. I combine 3D geometric morphometrics and maximum likelihood modelling to quantify regionalization in taxa across Reptilia and representative

tetrapod outgroups. I compare these models with anatomical, developmental, and ecological data to assess the potential drivers of axial skeleton diversity. I reveal multiple independent acquisitions of highly complex axial skeletons across Reptilia with equally high degrees of regionalization amongst crocodylians, squamates and birds, as well as mammalian outgroups. Comparison with developmental data illustrates variation in *Hox* expression underlying diversity in regionalization. In Maniraptora, posterior cervicothoracic shifts are conferred by posterior shifts in anterior expression of *Hox-PG6*. In crocodylians, the cervicothoracic boundary is traditionally placed between vertebrae nine and ten, reflected in the anterior expression of *Hox-C6* and *-C8*, however I find that these expression boundaries confer changes in rib morphology at this position with no concurrent effect on vertebral regionalization. Comparison of modelled regionalization and heterogeneity with ecology include a lack of association between volancy and regionalization, and significant associations between highly regionalized anatomies and semi-aquatic habits. Fully aquatic and fossorial taxa have significantly more heterogeneous axial skeletons than other taxa. These results contradict assumptions of simple linear increases in regionalization across Vertebrata, reveal previously unknown levels of complexity in axial skeleton evolution across Reptilia, and how these relate to development and ecology. Highly regionalized anatomies are not unique to mammals. Instead I reveal that reptiles have the most diversely regionalized and complex axial skeletons among tetrapods, and potentially among all vertebrates.

Funding Sources NERC ESS DTP Studentship

Technical Session 16: Hoofed Mammals (Saturday, November 5, 2022, 8:00 AM)

THE SUBARCUATE FOSSA MORPHOLOGY OF SOME EXTINCT CAMELINES

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The first Camelinae are known from the Miocene of North America, and both extant tribes (Camelini and Aucheniiini) originated in North America. Following recent work on camelina relationships, the phylogenetic positions of some extinct camelines have come into question. This includes *Procamelus* and *Camelops*. *Procamelus* has historically been considered a basal camelinin, but recent phylogenetic analyses recover *Procamelus* either within Aucheniiini or outside of the camelid crown. Conversely, *Camelops* has historically been placed within Aucheniiini, but recent phylogenetic analyses recover the genus within Camelini. This ambiguity suggests that additional independent lines of evidence may be needed to resolve evolutionary relationships within Camelinae. To this

end, we examined the petrosal morphology of *Procamelus* and *Camelops*, along with the giant camel *Megatylopus*, and compared them to the petrosals of basal and extant camelids. Camelid petrosals are fairly conserved in their morphology, except in one regard; extant camelids have a greatly reduced subarcuate fossa. Therefore, we focused our examination on subarcuate fossa morphology. *Procamelus* retains the ancestral camelid condition, having a deep subarcuate fossa that contains a mastoid fossa. This retention is unsurprising given that *Procamelus* is one of the earliest known camelines. *Megatylopus* is a younger taxon, originating in the late Miocene, and it is the only definitive extinct camelinin in our dataset. Although the specimens of *Megatylopus* that we sampled had postmortem deformation, we were able to accurately reconstruct the petrosal. *Megatylopus* has a distinct subarcuate fossa but with a more constricted opening, similar to that of *Camelus bactrianus*. This suggests that subarcuate fossa reduction began basal to crown group Camelini. The subarcuate fossa of *Megatylopus* may be deeper than that of *C. bactrianus*, but exact comparisons cannot be made because of the deformation. *Camelops* originated in the middle Pliocene, making it the youngest extinct taxon in our sample. *Camelops* has an intermediate morphology between *Procamelus* and *Megatylopus*; the subarcuate fossa of *Camelops* is wider and possibly deeper than that of *Megatylopus*, but not quite as large as that of *Procamelus*. *Camelops* is most similar to the guanaco, *Lama guanicoe*. If the placement of *Camelops* as a basal camelinin is accepted, this suggests that subarcuate fossa reduction is confined to *Camelus* and its closest extinct relatives.

Funding Sources This work was funded by a Paleontological Society Student Research Grant awarded to SVR and an NSERC Discovery Grant awarded to JMT.

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

SEBEK IN THE AMERICAS: TOOTH VARIATION IN LANGSTONIA HUILENSIS (SEBECIDAE: NOTOSUCHIA CROCODYLOMORPHA) WITH COMMENTS ON PREDATION STRATEGY

Rock, Andrew A.¹, Herrera-Martinez, Alexandra¹, Daza, Juan D.¹, D'Amore, Domenic², Campbell, Timothy L.³

¹Sam Houston State University, Huntsville, Texas, United States, ²Daemen College, Amherst, New York, United States, ³Anthropology, Baylor University, Waco, Texas, United States

Langstonia huilensis is a middle Miocene taxon from La Venta Colombia and formerly described as part of the genus *Sebecus*. These genera are part of a terrestrial clade of ziphodont crocodyliform taxa that diversified in South America, although the oldest member of the group (*Ogresuchus furatus*) is from the Late Cretaceous of Spain. There is abundant dental material from La Venta Colombia that has been previously described, but, given the lack of a complete skull, the variation and allocation of teeth has not

been determined. Here we use CT and laser surface scans from several teeth, including new material to further detail the heterodonty and degree of ziphodonty in this taxon. We use as reference the dentition of *Sebecus icaeorhinus* from the Eocene of Argentina, as well as members of the modern genus *Caiman* and *Alligator*, for comparison with *Langstonia*. Morphological characteristics of interest include the orientation of the apex (curvature), the existence of denticles on the carinae, and the degree of labio-lingual compression. For this latter metric, empty alveoli were used as a proxy for absent teeth. Both sebecids have a greater lateral compression in most of their crowns than *Caiman*. Distal curvature was most pronounced mid-maxillary sebecid teeth, although the distal-most teeth did not differ from modern taxa in this aspect. Denticles are absent in *Caiman*, but are present on both carinae in sebecids. Several sebecid teeth include a posterior flattened ridge that might have provided an additional shearing surface. Because the death roll is widespread in extant aquatic crocodiles, we propose that terrestrial crocodyliformes were incapable of generating shearing forces using this behavior and convergently evolved ziphodont dentition like that of theropod dinosaurs. Due to differences in distal curvature, we do not assert that sebecids used the typical theropod ‘puncture-and-pull’ method for processing carcasses either. Ziphodont crocodyliformes may therefore have been fundamentally unique in how they captured and processed prey.

Funding Sources Department of Biological Sciences, Sam Houston State University

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

THE FIRST KNOWN MODERN WALRUS FROM OREGON: A DESCRIPTION OF A PARTIAL SKULL OF *ODOBENUS ROSMAREUS* (MAMMALIA, CARNIVORA)

Rodgers, Jordan M., Tate-Jones, Kellum

Paleontology, University of Oregon, Eugene, Oregon, United States

In this study we describe the first fossil specimen of the modern walrus, *Odobenus rosmarus* from the Oregon coast. Although incomplete, this skull includes the right tusk, four premolars, the maxilla, the premaxilla, the anterior palatal foramen, the frontal bone, a portion of the jugal, and a portion of the nasal cavity. The skull measures 17.8 cm high from the dorsal-most extent of the maxilla to the ventral extent of the maxilla. The amount of wear on the premolars suggests this individual was a mature adult. Although this species is extant, this individual lived during the Pleistocene in a latitude that modern walruses do not reach, demonstrating that during that interval, the geographic range of walruses extended much further south. This occurrence is unexpected given assumed temperature and resource constraints of walruses based on their modern ecology, suggesting the realized niche of walruses today is a smaller proportion of their fundamental

niche than had been suspected. This specimen also suggests that the Oregon Coast pinniped fauna was both more species-rich and ecologically diverse than what is found today. Further studies could reveal whether the ecological niche of Pleistocene walruses differed from that of modern members of the same species.

Education & Outreach Poster Session

ABUSE, HARASSMENT, AND DISCRIMINATION ARE FREQUENT ETHICAL ISSUES AMONG BRAZILIAN PALEONTOLOGISTS: A CALL FOR ROBUST D.E.I. POLICIES

Rodrigues, Taissa¹, Oliveira-Ciabati, Livia², Holanda, Elizete³, Figueiredo, Ana Emilia⁴, Dentzien-Dias, Paula⁵, Hsiou, Annie S.⁶

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One of the major causes of the so-called “leaking pipeline” of minorities in Science is facing discrimination and abuse in the workplace. And, although this is a well-known issue that has been approached by institutions, funders, and professional societies, there have been very few studies aimed at gathering quantitative data on the matter. We thus organized the project Gender Profile of Brazilian Paleontologists which, among other goals, aimed to make a diagnosis of discrimination, harassment, and abuse among this cohort. Between 02/24/2021 and 04/22/2021, we collected answers from an online survey aimed at paleontologists from or working in Brazil. In total, 427 respondents answered the survey, among them 208 cisgender men (CM), 206 cisgender women (CW), and 13 non-binary or transgender persons (NBTP). 56% of CM, 76% of CW, and 77% of NBTP declared they had already suffered discrimination, abuse, or harassment in their academic career. Given multiple options, among CM 43% reported suffering moral harassment, 22% psychological abuse, 16% verbal abuse, and 12%, bullying. 50% of CW informed moral harassment, 46% gender discrimination, 30% psychological abuse, and 19%, verbal abuse. 54% of NBTP reported moral harassment, 31% discrimination against their sexual orientation/LGBTphobia, 31% psychological abuse, 31% verbal abuse, 23% bullying, and 23%, gender discrimination. We also asked who their harassers or abusers were. 28% of CM reported other men only, 20% both men and women, and 8%, only women. 50% of CW reported being victims only of men, 25% of both men and women, and 1%, only of other women. 46% of NBTP reported abuse, discrimination, or harassment from men only, 31% from men and women, and none from only women. We also asked respondents if they had ever witnessed discrimination, abuse, and/or harassment towards others in their workplace: 74% of CM, 73% of CW, and 77% of NBTP said yes. More

frequently, they witnessed moral abuse, gender discrimination, sexual harassment, verbal abuse, discrimination against sexual orientation/LGBTphobia, and racial or ethnic discrimination. These data show that there is an urgent need for more robust institutional policies against anti-ethical behaviors in Brazil. We suggest that, despite ethics being an infrequent topic at academic meetings, talks, presentations, and roundtables on the matter should be an integral part of the programs to promote safer, more inclusive working environments for paleontologists.

Virtual Posters

DENTAL MESOWEAR ANALYSIS OF THE COLUMBIAN MAMMOTH (*MAMMUTHUS COLUMBI*) FROM TULTEPEC, ESTADO DE MÉXICO, MÉXICO

Rodríguez-Franco, Susana¹, Perez-Crespo, Víctor A.², Barrón-Ortiz, Christina Isabelle³, Córdoba-Barradas, Luis⁴, Arroyo-Cabrales, Joaquín⁵

¹Posgrado en Ciencias Biológicas, UNAM. Edificio A, 1° Piso, Circuito de Posgrados, Ciudad Universitaria, Coyoacán, C.P. 04510, Distrito Federal, México., Ciudad de México, Mexico, ²Universidad Nacional Autónoma de México Instituto de Geología, Ciudad de México, Ciudad de México, Mexico, ³Quaternary Palaeontology Program, Royal Alberta Museum, Edmonton, Alberta, Canada., Edmonton, Alberta, Canada, ⁴Dirección de Salvamento Arqueológico, Instituto Nacional de Antropología e Historia (INAH), México., México, Mexico, ⁵Laboratorio de Arqueozoología “M. en C. Ticul Álvarez Solórzano”, Subdirección de Laboratorios y Apoyo Académico, INAH, México., Ciudad de México, Mexico

Ontogenetic age and food preferences from 11 individuals pertaining to *Mammuthus columbi* from Tultepec, State of México, México, were estimated using mandibles and molars qualitative and quantitative characters, and analyzing dental mesowear from those molars. Estimated age based on African Elephants Age was on most individuals less than 30 years, and just one was older at about 45 years; mesowear analysis results show that specimens were feeding on both C₃ and C₄ plants, as mixed feeders, and there were also some that were mostly C₄ feeders. That indicates that Tultepec mammoths were able to consume different food resources, but further studies utilizing microwear analysis should help in better understanding their feeding habits.

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Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

FURCULA OR JUST A WISH BONE? A CALL FOR STANDARDIZATION IN THE IDENTIFICATION OF *T. REX* FURCULAE

Rooney, Laura A., Anné, Jennifer

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Within the past 30 years, furculae have been identified in several tyrannosaurid specimens, although many of those belonging *Tyrannosaurus rex* have been a subject of great debate. In particular, those belonging to FMNH PR2081 and TCM 2001.90.1 (previously referred to as CMI 2001.90.1) have been speculated to be partial ribs from the posterior-most dorsal vertebra rather than furculae. This determination was made based on the specimens' asymmetry and a supposed lack of an articular surface at the epicleideum. However, other researchers have stated that these bones lack sufficient similarities with other dorsal ribs and they do not properly match up with the shape of the articular facets on the posterior-most dorsal vertebra. This controversy highlights a need for an established standard for identifying *T. rex* furculae. Here we present CT scans of the “furcula” of TCM 2001.90.1 and propose that comparisons with CT scans of unambiguous furculae from other *T. rex* specimens (e.g. UCRC V1) may aid in establishing this standard.

Technical Session 17: Fish (Saturday, November 5, 2022, 8:00 AM)

OSTEICHTHYANS AND CHONDRICHTHYANS OF THE UPPER TRIASSIC HOMESTEAD SITE OF EAST-CENTRAL NEW MEXICO, U.S.A, ALONG WITH A COMPARISON OF LUNGFISH (SARCOPTERYGII: DIPNOI) TOOTH PLATES FROM OTHER TRIASSIC LOCALITIES ACROSS THE AMERICAN SOUTHWEST

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The Homestead Site of east-central New Mexico occurs in the Garita Creek Formation and is Late Triassic in age, specifically Adamanian–Revueltian (early-mid Norian). Although dominated by tetrapods, the site contains a wide array of fossil material belonging to osteichthyans and chondrichthyans. Chondrichthyans are represented by nine teeth (four complete) of *Reticulodus*, a durophagous hybodont shark with superficially batoid-like teeth known primarily from strata of Revueltian age in the American Southwest. The

majority of the osteichthyan material is assigned to Actinopterygii. Not counting specimens preserved in coprolites, there are approximately 18 scales, 17 scale fragments, nine skull fragments, nine “crusher plates” (dentigerous elements), seven teeth, five vertebrae, and a single maxilla fragment with three inset conical teeth and a fourth broken one. Out of the 35 total scales, 12 are smooth ganoid scales, possibly of redfieldiids. Many scales preserve complex grooves and ridges and may pertain to palaeoniscoids. Sarcopterygians make up a small portion of the Homestead Site assemblage, but include both Actinistia and Dipnoi. There are two coelacanth jaw fragments, each with inset conical teeth, as well as four complete lungfish tooth plates and 14 more tooth plate fragments. The lungfish tooth plates are particularly interesting due to their distinct shape, which makes them easily recognizable. Each individual lungfish has only four interlocking teeth adapted for durophagy and are not replaced during their lifetime. We compared the Homestead Site lungfish tooth plates to others collected from the Bluewater Creek Fm, NM, Petrified Forest Fm, AZ, and Monitor Butte Fm, UT. Lungfish teeth vary immensely in shape and size between genera and species. Because of this variation, assigning them to a position and taxon is difficult. Position assignments are based on the direction, number, size, and shape of the crests along with the furrows separating each crest. All tooth plates are hypothesized to belong to Arganodus based on the presence of a singular defined mesial angle and the palatal tooth plates having 6-7 crests. The Homestead Site yielded a left splenial, one right and two left palatal tooth plates. The Bluewater Creek Fm site has a right splenial and a right palatal tooth plate. The Petrified Forest Fm site has one right and two left palatal tooth plates, and the Monitor Butte Fm site has a right palatal and three left splenial tooth plates.

Funding Sources Lauer Foundation for Paleontology, Science and Education, Appalachian State University Office of Student Research and Department of Geological and Environmental Sciences

Technical Session 3: Marine Reptiles (Wednesday, November 2, 2022, 8:00 AM)

TRIPLE OXYGEN ISOTOPES FROM SKELETAL CARBONATES AS A PROXY FOR HABITAT IN EXTANT AND EXTINCT TESTUDINES

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Sedimentology, phylogeny, and morphology can be problematic lines of evidence when used to infer habitat preferences of extinct aquatic organisms, particularly when they are discordant with one another. Isotope geochemistry of fossils holds potential to resolve such conflicts. Hydrologic and atmospheric features of an environment carry distinct ratios of stable isotopes, which are mineralized in an

organism’s tissues over the course of its life. To explore the utility of the stable oxygen isotope record for paleoecological reconstructions, we analyzed the ratios of $^{18}\text{O}/^{16}\text{O}$ and $^{17}\text{O}/^{16}\text{O}$ in the carbonate of skeletal apatite from extant turtles collected in terrestrial, freshwater, brackish, and marine habitats. We compared the oxygen isotope composition of two Cretaceous *Bothremydidae* side-neck turtles collected from shallow marine sediments to the distinct extant turtle apatite oxygen isotope signatures from each of the habitats, and found that that one of the fossils, *Chedighaii barberi* from the Niobrara Fm. of Kansas (YPM VP.003608), clustered with the freshwater and brackish turtles, and the other, *Taphrosphys sulcatus* from the Hornerstown Fm. in New Jersey (YPM VPPU.018706), may have been diagenetically altered but was closer to marine turtles than any other habitat group. Our results suggest that oxygen isotope ratios of apatite are a useful paleohabitat proxy in fossil *Pan-Testudines*, though we caution that only specimens from similar ontogenetic stages should be compared in multi-species analyses because habitat preferences can change during a turtle’s lifetime. Ultimately, we conclude that oxygen isotope composition of turtle apatite could provide decisive evidence for the habitat preferences of key early-diverging taxa – *Eunotosaurus*, *Eorhynchochelys*, *Pappochelys*, and *Odontochelys* – enabling us to infer the habitats in which turtles originated.

Funding Sources NSF EAR-1952615 and a student grant from the Yale Analytical and Stable Isotope Center.

Technical Session 16: Hoofed Mammals (Saturday, November 5, 2022, 8:00 AM)

PERISSODACTYLA KEEPING THEIR COOL: APPARENT VASCULAR PLEXUS-RELATED THERMOREGULATION, PRESENT AT LEAST SINCE THE PLEISTOCENE

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Recent recognition of a thermoregulation-attributable supra-parietal vascular plexus in Suidae stimulated survey of another group of ungulates that express similar mud hole-wallowing heat-dissipation behaviors, extant and extinct Perissodactyla for skeletal evidence of the same phenomena.

The parietal bones of extant and extinct Perissodactyla were assessed by surface microscopy for evidence of the characteristic open lattice pattern, which apparently marks the presence of a vascular plexus (in contrast to the trans-phylogenetic, but isolated trans-cortical vessels responsible for 70% of normal bone nutrition).

The open lattice pattern was recognized on the posterior aspect of the parietal bones of all extant (*Tapirus terrestris*, *T. pinchaque*, *T. bairdii* and *T. indicus*) and extinct (*Platygonus compressus*) Tapiridae and in extant *Dicerorhinus*

sumatrensis. Trans-cortical vascular channels were noted in extant *Rhinoceros unicornis*, *Diceros bicornis* and *Ceratotherium simum* and Equidae (*Equus asinus*, *E. hemionus*, *E. caballus*, *E. grevyi* and *E. burchelli*), but no open lattice pattern was observed in those species.

The open lattice ectocranial parietal structures, characteristic of vascular plexi, were recognized in both extant and extinct Periossodactyla that shared the common behavior, wallowing in mud holes. Evidence for origin of the supra-parietal vascular plexus identifies its existence at least since the Pleistocene. The presence of the lattice structures suggests the presence of a physiologic mechanism, a countercurrent thermoregulation system, for further dissipating the intense heat related to the metabolically-demanding, but temperature-sensitive process involved in neuronal (e.g., brain) function. The phylogenetic distribution of the phenomena is in keeping with the environmental conditions that compromise heat loss of affected species and the mud-wallowing habits that supra-parietal vascular plexus-manifesting animals pursue.

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

SKELTAL ANATOMY OF THE EARLY PERMIAN PARAREPTILE *DELORHYNCHUS CIFELLII* WITH NEW INFORMATION PROVIDED BY NEUTRON TOMOGRAPHY

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This study focuses on the holotype of the acleistorhinid parareptile *Delorhynchus cifellii*. The fossil record indicates that acleistorhinids were one of the first groups of parareptiles to diversify, and are represented by six taxa in the early Permian of Oklahoma. These taxa include two species of *Colobomycter*, three species of *Delorhynchus*, and one species of *Acleistorhinus*. In addition, the acleistorhinid taxon *Karutia* has been described from South American material. While the cranial anatomy of acleistorhinids has been previously described in some detail, very little is currently known about their internal anatomy or postcrania. The holotype of *Delorhynchus cifellii* is unique among acleistorhinid material in that the cranium is preserved in near perfect articulation in association with the vertebral column and shoulder girdle. It is ideally suited for neutron computer tomography and segmentation because much of the specimen is covered with partially disarticulated cranial material from a varanopid, obscuring much of the skeleton from direct observation. Three-dimensional rendering of this specimen has revealed detailed anatomy of the interior skull roof, palate and mandible in addition to elements of the neurocranium. Surprisingly, the supraoccipital-opisthotic-prootic complex is large and the component elements are ossified without distinct sutures, and the stapes is massive with a substantial dorsal

process. Neutron tomography has also revealed that there is a nearly complete and partially articulated presacral vertebral column starting from the atlas-axis complex, permitting detailed examination in variation of vertebral anatomy between the cervical, thoracic and posterodorsal regions of the skeleton. Tissue-level examination of the completely preserved shoulder girdle reveals patterns of ossification of the component elements including the scapulocoracoid, demonstrating that despite the lack of any external sutures there are three internal areas of ossification, a dorsal scapula and both anterior and posterior coracoids. The results of this research provide a significant source of new data for the next stages in studies of early amniote evolution.

Funding Sources NSERC Discovery Grant to Robert Reisz

Technical Session 15: Theropods (Saturday, November 5, 2022, 8:00 AM)

A REASSESSMENT OF *COELURUS FRAGILIS*

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In the last half-century coelurosaurs have been the focus of an enormous amount of research, due in large part to their role in understanding the origin of birds. The Late Jurassic *Coelurus fragilis* was one of the first coelurosaurs described, and is the namesake of this diverse and successful clade. It is known from a number of disarticulated specimens, most notably YPM VP 2010, which includes a partial dentary, cervical, dorsal and caudal vertebrae, partial pelvic girdle, and partial fore- and hindlimbs. *Coelurus* has a complicated taxonomic history, and has been synonymized with both *Elaphrosaurus agilis* and *Ornitholestes hermanni* in the past, though it is now considered a valid taxon. Within the last several decades *Coelurus* has consistently been found as an early-diverging coelurosaur, often as an early member of Tyrannosauroidae. Here we present the most exhaustive comparative analysis of the morphology of *Coelurus fragilis* using firsthand observations of the material and CT scans of the vertebrae and dentary. Several features, including the presence of elongate cervical vertebrae with low neural spines, the position of zygapophyses directly lateral to the neural canal, and a strongly convex ventral surface of the pubic boot suggest that *Coelurus fragilis* is more derived than Tyrannosauroidae. *Coelurus fragilis* also demonstrates a number of features uncommon in coelurosaurs, like the presence of twin pleurocoels in the cervical centra, a feature that is a synapomorphy for ceratosaurs, though also seen in therizinosauroids and the dromaeosaur *Achillobator giganticus*. The narrow, bowed, strap-like dentary is similar to the dentary of *Ornitholestes hermanni*, alvarezsosaurs and even some noasaurine ceratosaurs. This mosaic of derived and primitive

traits requires that *Coelurus* be analyzed in a matrix with a comprehensive taxonomic sample. To investigate the phylogenetic position of *Coelurus fragilis*, we are constructing a new phylogenetic matrix based upon the latest iteration of the Theropod Working Group (TWiG) matrix, with a vastly expanded taxonomic and character sample and illustrations of all character states. We score *Coelurus fragilis* in both the current TWiG matrix and a preliminary version of our new matrix based upon our re-evaluation of its anatomy, and present a revised opinion on its phylogenetic position and bearing on the sequence of character acquisitions that characterize coelurosaurian dinosaurs.

Funding Sources Yale Institute of Biospheric Studies doctoral pilot grant

Colbert Prize Session

A NEW ADAPIFORM (EKGOWECHASHALIDAE, PRIMATES) FROM THE NADUO FORMATION (LATE EOCENE) OF SOUTHERN CHINA REVEALS AN ASIAN ORIGIN FOR THE ENIGMATIC NORTH AMERICAN PRIMATE *EKGOWECHASHALA*

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Adapiform primates are a diverse clade that is abundantly represented in Eocene mammalian faunas of North America, Europe, and Asia. While most adapiforms go extinct by the early Oligocene, those in Asia survive into the late Miocene. Here, we identify a new adapiform from the Naduo Formation (late Eocene) of Guangxi Zhuang Autonomous Region, southern China, and discuss its implications for understanding the evolution and biogeography of Asian and North American taxa. Our study also elucidates the origin and evolutionary history of *Ekgmowechashala*, an enigmatic adapiform known from the early Arikareean of South Dakota, Nebraska and Oregon. The new Chinese taxon is represented by several partial dentaries preserving premolars and molars (P₂-P₃, M₁-M₂) and one maxillary fragment preserving M². To understand the evolutionary affinities of the Chinese Eocene taxon, we performed a phylogenetic analysis that sampled 46 taxa and 1032 morphological characters. Our results recovered a sister-taxon relationship between *Ekgmowechashala* and the Chinese Eocene taxon with high statistical support and reinforce the monophyly of Ekgmowechashalidae, a clade of adapiforms from the late Eocene to the late Oligocene of Asia and North America. Morphological comparisons between the new Chinese Eocene taxon and *Ekgmowechashala* reveal several synapomorphies including mesially canted lower premolars, low tooth crowns with bulbous cusps and crenulated enamel, the presence of lower molar metastylids, and a duplicated

protocone on M². Morphological comparisons with other Asian ekgmowechashalids (*Gatanthropus*, *Muangthanhinus*, and *Bugtilemur*) reveal additional shared dental features, supporting close affinities among these taxa. Results from our study suggest that Ekgmowechashalidae originated in Asia and that southern Asia served as a refugium for these adapiforms during the cooler, drier climatic conditions around the Eocene-Oligocene boundary. Our study clarifies the origin and evolutionary history of *Ekgmowechashala*, revealing several dental morphoclines that clarify the sequence of morphological evolution within a biogeographically complex Ekgmowechashalidae.

Funding Sources This study was supported by the University of Kansas, the David B. Jones Foundation, the Chinese Academy of Sciences, & the National Natural Science Foundation of China.

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

A PUTATIVE SPADEFISH (ACANTHOMORPHA: EPHIPPIDAE) FROM THE INDO-PACIFIC REGION AND ITS IMPLICATIONS FOR MARINE FISH BIOGEOGRAPHY IN THE PALEOGENE

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Ephippidae (spadefishes) is a clade of marine fishes containing 15 extant species divided among 8 genera. Found on coral reefs and in open waters worldwide, ephippids are laterally compressed fishes with small, non-protrusive mouths and often bear striking, dark vertical bars of pigmentation on their flanks. Apart from so-called “Tilly bones,” fossil hyperostotic elements attributed to ephippids and other tropical fishes, the paleontological record of ephippids is poor. Articulated remains of putative ephippids derive almost exclusively from the early Eocene (Ypresian, ca. 49 Ma) deposits of Bolca, Italy, and include two extinct genera: *Eoplatax* and *Archaeophippus*. Today the greatest diversity of extant spadefish species is in the Indo-West Pacific, yet there are no known fossil ephippid remains from this region. Here we report the first fossil spadefish from the Indo-Pacific, from the middle Eocene (Lutetian, ca. 47 Ma) Habib Rahi Formation of western Pakistan. Preserved as an impression on a limestone slab, this single articulated individual does not preserve definitive synapomorphies of ephippids, such as the branchial skeleton, dentition, and pelvic girdle. However, intact portions of the skeleton correspond closely to the anatomy of *Eoplatax* from Bolca. Major similarities include a nearly circular body, greatly elongated dorsal- and anal-fin rays, and a very deep caudal peduncle. The discovery of an *Eoplatax*-like fossil in the middle Eocene of Pakistan could have important implications for marine fish biogeography in the Paleogene. At this time, Indo-Pakistan is thought to have been outside the margins of an ancient biodiversity hotspot

centered in the West Tethys. The presence of similar faunal elements in the ancient Indo-Pacific can help to constrain models of shifting biodiversity hotspots during the Cenozoic. Such hotspot migration is supported by fossil evidence as well as patterns of relationships among some extant groups. Integration of putative fossil ephippids, including the new form from Pakistan, into a phylogenetic framework with living examples will be critical for determining what—if any—bearing spadefishes might have on these broad biogeographic questions.

Funding Sources NSF DEB 2017822, Rackham Merit Fellowship from the University of Michigan

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

A NEW EARLY CRETACEOUS ASSEMBLAGE OF IGUANODONTIAN DINOSAURS FROM WESTERN GERMANY

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The Lower Cretaceous (Barremian-Aptian) fissure filling at Balve in North Rhine-Westphalia (Western Germany) has yielded a diverse vertebrate fauna, comprising selachians, osteichthyes, amphibians, squamates, crocodiles, turtles, pterosaurs, theropod, sauropodomorph, and ornithischian dinosaurs, as well as mammals. The locality has been excavated since 2002 by the LWL Museum of Natural History in Münster and regular field seasons still provide new material every year. Within the past two decades a variety of ornithopod remains were uncovered at Balve. These comprise cranial remains (a partial dentary and isolated teeth) as well as postcranial material, including vertebrae, ribs, a sacrum, a scapula, pollex claws, and pelvic, and limb bone elements. The specimens can be largely assigned to *Iguanodon*-grade styracosternans. While most elements are isolated and show taphonomic wear, at least some equally sized vertebrae and the sacrum were found in close association and may belong to a single, immature individual. Larger elements (e.g., a vertebral centrum) match the size of adult *Iguanodon bernissartensis* specimens. Peripheral skeletal elements (pedal bones and caudal vertebrae) dominate quantitatively. Large bones are prone to be fragmented. The material potentially includes a robust and a gracile morphotype, but the disarticulated preservation and the presence of various ontogenetic stages require further investigation. The potential co-occurrence of a robust and gracile form would mirror coeval occurrences from England, Bernissart (Belgium), and

the geographically close Nehden locality in Brilon (Germany). The depositional setting at Nehden likewise represents a subterranean fissure system in uplifted, karstified Paleozoic limestones. Two styracosternan taxa, interpreted as *Iguanodon* and *Mantellisaurus*, occur in the lower Aptian strata of Nehden. However, the preservation of the Nehden and Balve material differs significantly. The specimens from Balve are almost exclusively isolated and fragmentary, while those from Nehden comprise isolated bones and partially associated skeletal parts. The preservation at Nehden is also more homogeneous but the associated fauna from Balve is more diverse. Even though the preservation complicates the taxonomic assessment, the abundance of iguanodontian fossils found at Balve (being continually enriched each year), represents a significant addition to the European Early Cretaceous ornithopod record.

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Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

FUNCTIONAL DRIVERS OF EVOLUTIONARY RATES IN MANDIBLE SHAPE OF CARNIVOROUS THERIAN MAMMALS: A STUDY USING BIOMECHANICAL MODELING AND GEOMETRIC MORPHOMETRICS

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Evolution of the mandible in mammalian carnivores is influenced by ecological demands and the phylogenetic history of a clade. Because of this, analysis of functional morphology of the mandible has been used to infer the ecology of extinct mammal species and how mandible shape has evolved in regards to these factors. This study uses geometric morphometrics to assess relative rates of evolution in different parts of the mandible during acquisition of carnivoran in several therian clades including Metatheria, Mesonychia, “Creodonta,” and Carnivoramorpha and uses biomechanical modeling to partition the evolution changes into several potential functional biomechanical drivers. Functional variables analyzed include maximum bending force, relative mandibular force in bending (both using the concept of beam theory), and bite force exemplified in measurements such as mechanical advantage.

The analysis of the evolution of the shape of the mandible of therian carnivores shows an integrated relationship between the horizontal ramus and the coronoid body of the mandible where the coronoid body shows higher rates of evolution and may be a greater driver of mandible shape than the horizontal ramus. Measured functional variables support that the coronoid body is a greater influence on the overall shape of the mandible. Specifically, mechanical advantage (which measures the in-lever provided by muscle attachments around

the coronoid body) explains as much as 40% of variance in phylogenetic diversity of mandible shape, and relative mandibular force from beam theory (which were measured along the horizontal ramus) explains as much as 18% of phylogenetic diversity in mandible shape. Mechanical advantage measurements explain more of the variance in shape than the beam theory measurements around the horizontal ramus reflecting the influence of the coronoid body on mandibular shape evolution. Regression of these variables on Procrustes-aligned shape on biomechanical factors show that as the latter get larger, mandibular shape changes by shortening and thickening of the mandible, increasing areas of muscle attachment, and increasing carnassial blade length. Specifically, the mechanical advantage with the temporalis includes thickening of the canine area, increased coronoid height (and temporalis attachment area), and masseter attachment area. Masseter area is more controlled by the posterior section of the dentition than the rostral section.

Funding Sources Norman R. King Graduate Field Research Fellowship
Galloway Perry Horowitz Fellowship

Technical Session 3: Marine Reptiles (Wednesday, November 2, 2022, 8:00 AM)

NEW MARINE REPTILE (PLESIOSAUR AND MOSASAUR) FOSSILS FROM THE UPPER CRETACEOUS DUWI FORMATION OF THE DAKHLA OASIS AREA, WESTERN DESERT OF EGYPT

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Upper Cretaceous deposits exposed in southern Egypt, near the Dakhla Oasis in the Western Desert, preserve abundant vertebrate fossils from nearshore marine paleoenvironments. Fieldwork carried out by researchers from the Mansoura University Vertebrate Paleontology Center in this area during 2008, 2010, 2011, and 2013 resulted in the discovery of numerous new vertebrate fossil localities within the upper Campanian part of the Duwi Formation. Fossils recovered from this unit include those of sharks, sawfishes, actinopterygians, and marine reptiles (mosasaurs and plesiosaurs).

Here we report on elasmosaurid (Sauropterygia: Plesiosauria: Elasmosauridae) and mosasaurid (Squamata: Mosasauridae) fossils from the Duwi Formation. Elasmosaurids are represented by numerous large posterior cervical and dorsal vertebrae that are referable to this plesiosaur clade based on their possession of centra with lateral ridges and dumbbell-shaped articular facets. Mosasaurids are the most abundant and diverse marine reptiles recovered from the Duwi Formation, with many craniodental (e.g., dentaries and teeth with differing morphologies) remains and dozens of vertebrae having been identified as those of Mosasaurinae or Halisaurinae. Within Mosasaurinae, an isolated, robust, and globular tooth crown of *Globidens* and a complete tooth of *Carinodens* (identified on the basis of its lateral flattening and two relatively pronounced sulci) indicate the presence of Globidensini. Many fragmentary dentaries pertain to an indeterminate mosasaurine, with two of these preserving teeth in situ and another showing a replacement tooth developed within a resorption pit. One small, fragmentary dentary with two preserved teeth is referred to Halisaurinae based on the presence of small, striated, hooked, snake-like teeth. This fossil represents the first record of Halisaurinae from Egypt and the oldest occurrence of this group from northern Africa.

Egyptian mosasaurids ranged in size from small-bodied (~3 to 4 m) Halisaurinae to medium-sized (~6 to 8 m) Mosasaurinae, and were similarly diverse in morphology. Tooth crowns range in shape from cones adapted to pierce and hold, to bulbous teeth adapted to crush, to cutting blades; jaw morphology is also diverse. The new elasmosaurid and mosasaurid remains from the Duwi Formation therefore reveal high taxonomic and functional diversity and elevated endemism in the uppermost Cretaceous marine reptile faunas of northeastern Africa.

Funding Sources Mansoura University research grant, Leakey Foundation, Ohio University, and National Geographic Society/Waitt Foundation (W88-10).

Technical Session 9: Mammals (Friday, November 4, 2022, 8:00 AM)

CHANGES IN THE STRUCTURE OF RODENT AND LAGOMORPH FAUNAS THROUGH THE CENOZOIC OF NORTH AMERICA WERE INFLUENCED BY REGIONAL TOPOGRAPHY AND CLIMATE

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Rodent and lagomorph faunas in North America changed dramatically through the Cenozoic, with open-habitat specialists (characterized by increased tooth crown height and adaptations for burrowing, jumping, or running) becoming common as open and arid habitats spread. Prior studies have primarily focused on continental scale analyses, but comparisons of regional and local scale changes are key to understanding how individual faunas changed over time and the roles exerted by topography and local climate conditions on these faunal changes. Here, we use a database of all fossil rodents and lagomorphs in North America (nearly 1,200 species) compiled from several databases to compare faunas through time across nine distinct regions. For each species we compiled a list of locality occurrences, first and last appearance dates, tooth crown-height, and locomotion. For each region, we counted the number of species in each category and the number of localities present in 0.5 million-year intervals, and use these data to 1) contrast the proportion of species within categories in each region over time and 2) describe the earliest occurrences of specialist clades across regions. Our analyses reveal asynchronous changes in faunas across the continent. Multiple clades with high-crowned teeth and specialized locomotion (burrowing, saltatory, cursorial) show their earliest occurrences in relatively cool, arid regions at higher latitudes (Columbia Plateau, Northern Rocky Mountains, Northern Great Plains). Those same regions also shifted to faunas dominated by higher-crowned taxa earlier than other regions. These findings suggest aspects of ecomorphological evolution in rodents and lagomorphs were potentially driven by topographic complexity and volcanic activity. As environmental conditions changed through the Cenozoic, the attributes of open and arid-adapted clades likely facilitated their spread from tectonically and volcanically active regions across the continent. Further study at more local scales and more detailed comparisons to records of past climate and geologic history will help improve our understanding of faunal evolution in North America.

Technical Session 5: Amphibians & Early Reptiles (Thursday, November 3, 2022, 8:00 AM)

JUVENILE POSTCRANIAL SKELETAL ELEMENTS OF THE EARLY PERMIAN EUREPTILIAN REPTILE *LABIDOSAURUS*: NEW INFORMATION ON

SKELETAL ONTOGENY OF BASAL CAPTORHINID REPTILES

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Newly described specimens of the early Permian captorhinid reptile *Labidosaurus* (Amniota, Reptilia, Eureptilia, Captorhinidae) preserve both juvenile and adult components of the axial and appendicular elements. Materials collected by Everett Olson from the early Permian sediments of the Clark Fork Group (undivided) in Baylor County of north-central Texas include both mature and juvenile postcranial components of *Labidosaurus*. Olson's original collection data identified this locality as "Arroyo Formation" and designated the location the "*Labidosaurus* pocket". This collection of specimens includes those that were the basis of many earlier studies of mature structures of *Labidosaurus*. Re-examination of the entirety of collected materials reveals numerous additional disarticulated components, a significant proportion of which are reported here as juvenile representatives of the genus. The post-cranial skeletal components are interpreted here as juvenile *Labidosaurus* for the following reasons: neurocentral sutures of axial specimens are unfused and frequently disarticulated; the proximal and distal ends of the appendicular bones are incompletely ossified suggesting that cartilaginous epiphyses are not preserved; and, all specimens are smaller than adult examples of *Labidosaurus*, but larger than mature coeval captorhinids, including the extremely well-known genus *Captorhinus*. Vertebrae with unfused neurocentral sutures are less than 70% the maximal centrum width of adult vertebrae of *Labidosaurus*, but approximately 15% larger than mature vertebrae in *Captorhinus* with completely fused neurocentral sutures. Maximal width of proximal articular head of the largest humerus still demonstrating a juvenile condition is as much as 86% the width of fully ossified adult humeri of *Labidosaurus*, but more than 2.5 times the width of the humeral articular head in fully mature adult specimens of *Captorhinus*. Notably, no evidence of ossification of the supinator process is evident in the juvenile specimens of *Labidosaurus* (though this could be due to incomplete preservation). At least two different sizes of immature humeri at the same locality suggest that as many as three different size classes are preserved in the "*Labidosaurus* pocket".

Symposium: A Late Miocene Shangri-la (Wednesday, November 2, 2022, 1:45 PM)

THE MORPHOLOGY AND ECOLOGY OF THE EARLIEST PHASE OF *STEGODON* (*STEGODONTIDAE*, PROBOSCIDEA, MAMMALIA) AT THE SITE OF SHUITANGBA, ZHAOTONG, CHINA

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Excavations in lignite beds at Late Miocene (~6.2 Ma) Shuitangba, in the Zhaotong Basin of Yunnan, China, uncovered a rich, diverse vertebrate fauna of mammals, water birds, crocs, lizards, snakes, turtles and fish. Faunal composition suggests that these species inhabited a humid forest ecosystem. Numerous remains of the proboscidean *Stegodon zhaotongensis*, including partial skeletons, are present in the Shuitangba mammal assemblage. *Stegodon* was a highly successful Late Miocene-Late Pleistocene Asian taxon that emigrated to South Asia and Africa and converged with elephants in its horizontal shearing mastication and formation of molar lamellae. The Shuitangba *Stegodon* collection provides an unparalleled record of the morphology and adaptations of the skull, teeth, and postcrania of the most primitive phase of the genus. Limb elements are powerfully muscle-marked, and reconstruct shoulder height of ~300 cm. Regression analyses of femoral and humeral dimensions yield body mass calculations of 5025-5754 kg for lengths and 8469-10,459 kg for midshaft widths, consistent with the extreme robustness of the limbs. An extraordinarily well-preserved cranium is long, wide, relatively low, and has an impressively elongate rostrum. It exhibits a very short vault that is narrow across the temporal lines, abruptly downturned tusk alveoli, a short basicranium, and a very low, broad occipital planum. Tusks from the site are immense, relatively straight, and lack enamel bands. The mandible is brevirostrine with an elongate corpus and low ramus, and lacks lower tusks. Lamellar formulae are M2/m2=5/5 and M3/m3=6-7/8. Molars are formed of transversely straight lamellae of a modest number of conelets of equal size that are coated with cementum, are exceedingly brachyodont, and have immensely thick enamel, low lamellar frequencies, very broad crowns, no accessory conules, and nascent development of enamel stepping (“Stufenbildung”). Given the antiquity of these remains, it is unsurprising that they comprise a mix of traits typical of the ancestral morphological pattern in *Stegolophodon* and basal features of the craniodental complex that characterize *Stegodon*. Congruent with its low-crowned molars, isotopic analysis shows that *S. zhaotongensis* was a committed browser. The abundance of the proboscideans at Shuitangba suggests that they had significant effects on the physical infrastructure of the ecosystem and served as important seed dispersers and fertilizing agents.

Funding Sources NSF grants BCS 1035897, 1227964, 0321893, 1227927; Yunnan NSF, Government of Zhaotong 2010CC010; IVPP; National NSF, China 41430102; Governments of Zhaotong and Zhaoyang.

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

TOOTH FOSSIL REMAINS OF LATE MIOCENE (11.63–5.33 MA) LAND MAMMALS FROM NORTHERN PUNJAB, PAKISTAN

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The Siwalik Group represents one of the richest fossil bearing deposits in the world. Over the past two centuries, numerous fossil taxa have been described and presented to the world. Most of these taxa have been recovered and reported from Late Miocene deposits, including artiodactyls, perissodactyls (most abundant), proboscideans, rodents, carnivores (rarest), etc. The present work reports and describes 18 mammalian remains collected from the Khokhar Zer (Nagri Formation, 11.63–9.0 Ma) and Hasnot (Dhok Pathan Formation, 10.1–5.33 Ma) localities of the Late Miocene, Punjab, Pakistan. These remains belong to four orders: Artiodactyla, Perissodactyla, Proboscidea and Carnivora. Among the proboscideans, a small tusk fragment is reported that can be attributed to *Choerolophodon corrugatus* based on its oval cross section and lack of enamel. Carnivores and perissodactyls are represented by two specimens each. An isolated canine and premolar can be attributed to a female machairodontid due to the presence of small crown and highly crenulated edges, and two isolated upper premolars can be assigned to *Brachypotherium perimense* by large size, brachyodont and short but broad, and a tendency to flattened buccal walls. Artiodactyls are most abundant in the collection, dominated by bovids consisting of six fossil specimens attributed to *Tragoportax*, *Selenoportax*, and *Miotragocerus*; suids by *Propotamochoerus hysudricus* and *Hippopotamodon sivalense*, and anthracotherids by *Merycopotamus dissimilis*. Although the bovid specimens consist of isolated teeth, these will add more morphometric data to resolve the problems of the *Tragoportax/Miotragocerus* species complex. Also, the remains of machairodontids are extremely rare in the Siwaliks, and every new specimen is valuable in elucidating their relationship with other machairodontids of the world.

Funding Sources University of the Punjab, Lahore, Pakistan

Technical Session 16: Hoofed Mammals (Saturday, November 5, 2022, 8:00 AM)

A NEW METHOD TO TRANSLATE DENTAL COMPLEXITY OF HERBIVOROUS MAMMALS INTO NUMERICAL DESCRIPTORS: THE CASE STUDY OF HYPSONDONT RHINOS

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Enamel ridge architecture is key to understanding deep time evolutionary and ecological interactions in herbivore communities. However, potential ecological factors modulating enamel wall plication are yet to be explored in 2D with larger samples and modern deep-time quantitative techniques. The toolkit described in this work provides the instruments necessary to perform a comprehensive numerical description of the occlusal patterns of herbivorous mammal enamel by means of three parameters: enamel folding (EF), two-dimensional orientation patch count (2D OPC), and local thickness (LT) as useful descriptors of dental topography. To illustrate the process implemented by the current workflow, we explored the evolutionary fingerprint of dental complexity in two clades of rhinoceros species, the subfamily Elasmotheriinae and the subtribe Rhinocerotina within the subfamily Rhinocerotinae. The dataset includes 23 Elasmotheriinae and 24 Rhinocerotina species. The two distinct strategies to increase masticatory durability in hypsodont rhinos have their origins in two differing phenotypic and developmental pathways that diverged early in their evolutionary history: members of the Elasmotheriinae increased their enamel folding thus generating a higher number of orientation patches, while some Rhinocerotini thickened their enamel walls. In addition, our method has been tested for other practical scenarios, demonstrating that variations in image size or rotation do not affect the output.

Funding Sources Funding was provided by the Talent Attraction Program of the Madrid Gov. (2017-T1/AMB5298) and the University of the Basque Country UPV/EHU grant (GIU19/027).

Virtual Posters

NICHE PARTITIONING IN FOSSIL BOVIDS NEAR THE MIO-PLIOCENE BOUNDARY AT LOTHAGAM, TURKANA BASIN, KENYA

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The spread of environments dominated by C₄ biomass constituted a major shift in the structure of eastern African terrestrial ecosystems during the late Miocene and early Pliocene. Though previous work has shown that many families of large eastern African herbivores adopted C₄ diets during this time, we have little knowledge of how dietary resource

partitioning was structured at finer taxonomic scales, such as within the highly speciose and diverse bovid tribes. The Lothagam sequence (Turkana Basin, Kenya) spans the late Miocene to the Pliocene (~7.5 to 3.5 Ma) and has produced an abundant mammal fauna that is ideally suited for investigating how an increasing abundance of C₄ grasses influenced niche partitioning within the large herbivore guild. Here, we report new carbon stable isotope ($\delta^{13}\text{C}$) data for tooth enamel (n = 120) and body mass estimates from tooth measurements (n = 86) for bovid tribes from Lothagam. Linear models predicting $\delta^{13}\text{C}$ values and estimated body mass by time revealed no significant shifts, which implies most tribes were characterized by static dietary and body mass niches throughout the Lothagam sequence. Alcelaphins and bovins were both C₄-specialists but differed markedly in average mass (~65 kg versus > 100 kg, respectively). Tragelaphins were relatively large-bodied (~80 kg on average) and had the lowest average $\delta^{13}\text{C}$ values (-6.6 ‰), suggesting mixed-feeding with a preference for C₃ browse. Other taxa seem to have been C₃-C₄ mixed-feeders varying only by mass. We propose that this static pattern of niche partitioning reflects conservatism of divergent ecological strategies among bovid lineages that evolved to minimize competition following significant turnover in vegetation structure starting in the late Miocene.

Virtual Posters

LIFE HISTORY OF THE *ALLOSAURUS JIMMADSENI* SPECIMEN MOR 693 ("BIG AL") AS REVEALED BY TIBIAL HISTOLOGY

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In 1991, a nearly complete partially-articulated skeleton of the theropod dinosaur *Allosaurus jimmadseni* was excavated in the Jurassic Morrison Formation of Big Horn County, Wyoming. This specimen (MOR 693; "Big Al") is approximately seven meters in length and exhibits pathologies throughout its skeleton, including its ribs, manus, ilium, and pes with a particularly large exostosis of pedal phalanx III-1 that may have resulted from trauma and infection. Prior histologic examination of MOR 693 has targeted pathologic elements. Here we present preliminary results of the first analysis of MOR 693 limb bone histology in order to further assess the life history of this individual. Both tibiae were sectioned and each records 16 cyclical growth marks (CGMs) indicating a minimum age of 16 years. Despite its extensive pathologies, a high bone apposition rate was maintained

throughout growth with variable spacing between CGMs indicating the relative duration of annual growth arrests. Longer growth arrests are noted in years two, five, six, eight, and 12 with year six potentially representing a particularly difficult year based on a thin growth zone ending in a consistent triple CGM in both tibiae. A decrease in vascularity follows the thirteenth CGM. CGMs 14 through 16 may be within an incipient external fundamental system (EFS) although it is unclear if the asymptotic body size of MOR 693 is typical for *A. jimmadseni* or is instead related to stunting due to illness or injury. On the medullary-side of the lamellar endosteal layer, each tibia contains endosteally-derived woven tissue morphologically consistent with medullary bone (MB). This tissue was subsequently eroded and a second lamellar endosteal layer formed on its surface. This suggests that MOR 693 is a female *A. jimmadseni* which had not fully resorbed MB from a previous egg-lay cycle and as such was not gravid at the time of death. An alternate possibility is that this medullary bone-like microstructure could have developed as a biomechanical response to loading associated with injuries. Ongoing studies at both the macro and microscopic level continue to test these hypotheses regarding the life history of "Big Al."

Technical Session 20: Crocodylomorpha (Saturday, November 5, 2022, 1:45 PM)

THE DIVERSE YET NOT-SO-CONVERGENT TRANSFORMATIONS OF CROCODYLIFORMES TO THE AQUATIC REALM

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Crocodyliformes is a diverse and long-lived clade of archosaurs that thrived in many distinct environments. This ancient diversity is notably embodied by the semi-aquatic to marine clades Dyrosauridae and Thalattosuchia. Dyrosauridae is a clade of neosuchian crocodyliformes that diversified in fluvial and marine environments across the Cretaceous-Paleogene transition. Thalattosuchia is a clade of marine crocodyliforms which spanned over the Jurassic period and disappeared during the Early Cretaceous. Both clades crossed important extinction events (i.e., Jurassic-Cretaceous boundary for Thalattosuchia; Cretaceous-Paleogene boundary for Dyrosauridae). The postcranial anatomy of both groups has long been overlooked in anatomical descriptions and diagnoses, shrouding the locomotive adaptations that possibly underpinned their aquatic radiations.

We thoroughly surveyed the morphology of the girdle elements of Dyrosauridae, Thalattosuchia, and Crocodylia, and recreated their girdles in three-dimensions using several tens of high-precision 3D models. We identified osteological correlates for ecology and behaviour a comparative framework. In addition, we performed landmark-based geometric morphometric analyses on girdle elements (193

landmarks on scapulae, 194 on coracoids, 180 on humeri, 262 on ilia, 170 in ischia, 116 on pubes, 200 on femora) within the same three clades.

Dyrosauridae, Thalattosuchia, and Crocodylia appear well separated in our morphospaces. Extinct crocodyliform clades colonizing similar environments appear markedly distinct from one another, indicating the existence of clade-specific features limiting the strength of evolutionary convergence. As such, our work reveals the previously unsuspected potential of postcranial anatomy as an abundant source of phylogenetic characters to assess the relationships within crocodyliformes. Moreover, extant crocodylians do not appear as an optimal functional analogue for every group of extinct crocodyliformes, because they show a restricted range of postcranial morphologies compared to what has been evolved by dyrosaurids and thalattosuchians. Incorporation of postcranial anatomy therefore appears crucial to fully assess the ecology of extinct crocodyliforms and their disparity.

Funding Sources Fonds pour la Recherche Scientifique F.R.S.-FNRS (MIS F.4511.19 grant) to VF

Technical Session 2: Paleoecology (Wednesday, November 2, 2022, 8:00 AM)

BUILDING ECOMETRIC MODELS USING SMALL MAMMAL HYPHODONTY TO OBSERVE NOVEL TRAIT-ENVIRONMENTAL RELATIONSHIPS THROUGH TIME IN AFRICA

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By examining the relationships between fauna and climate through time, we can better anticipate how communities will respond to environmental changes. Ecometric analyses examine the relationships between functional traits and the environment at the community level. Traits used in these studies directly influence how an organism interacts with its environment. Previous studies using ecometrics have explored relationships between hypsodonty (tooth crown height) and precipitation and temperature. Many studies have analyzed this in large mammals. However, recent work found that hypsodonty in North American small mammal communities is correlated with mean annual temperature and annual precipitation. Here, we examined community-level hypsodonty of African rodents and lagomorphs to test if the same relationship exists across geographic space. Africa's rich biodiversity is of interest because it is expected to experience warmer, dryer climates in the near future. To investigate this trait-environment relationship in Africa, categorical hypsodonty values (brachydont, mesodont, and hypsodont) were gathered from the literature and museum collections for 91 modern taxa. Equidistant 50-km points were used to

generate community lists by sampling IUCN range maps across Africa. There was a stronger linear correlation between small mammal community-level hypsodonty and mean annual temperature (MAT; $r=0.54$, $p<.001$) than annual precipitation (AP; $r=0.14$, $p<.001$). However, both relationships were weaker than expected based on North American MAT ($r=0.86$) and AP ($r=0.66$) correlations. We next constructed novel ecometric spaces to describe the relationship between hypsodonty and temperature in Africa. Using maximum-likelihood estimation methods, we determine that the trait-based estimates of temperature were, on average, 10°C warmer than the observed temperature values. To explore this relationship through time, we placed 25 well-sampled fossil localities from East Africa into our ecometric spaces based on their trait composition. Ten sites are non-analog communities and occupy trait space not represented by modern communities, meaning temperature estimates are not possible. Half of these ten communities are Pleistocene in age and have higher mean hypsodonty values than are found in any modern African communities. Fossil sites can show how the traits of communities are shifting in response to environmental change by revealing the direction and magnitude of change over time.

Funding Sources Short – NSF-DBI 2010680, McGuire/Schap – NSF-CAREER 1945013

Virtual Posters

QUANTIFYING BONE GROWTH IN AN EXTANT REPTILIAN MODEL: IMPLICATIONS FOR HISTOLOGICAL STUDIES IN EXTINCT ANIMALS

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Lines of Arrested Growth (LAGs) are commonly used to determine life-history traits, metabolism, and age of animals; however, interpretations of LAGs from extinct animals are challenging to accomplish without using extant relatives as a model. In this study, we used fluorescent labeling in captive leopard geckos to track bone growth from embryonic to adult growth stages. Detailed analyses of bone growth through ontogeny in an extant reptile will inform on general patterns of bone growth and remodeling in extinct taxa.

Thirteen individuals were injected with fluorescent markers throughout life, from pre-hatching to four years of age. The left tibia, fibula, femur, humerus, radius, and ulna from each individual were examined histologically and compared for differences in the number of labels within each individual and between individuals. Weekly weights were recorded to track overall animal growth.

Results show that leopard gecko growth is rapid for the first 400 days of life, after which growth stabilizes, and new bone is deposited at a slower rate. The limb elements had differing

growth rates, where the fibula grew the fastest per day on average and the femur grew the slowest per day on average, which demonstrates that elements in the same limb can grow at varying rates.

In captive leopard geckos, prominent LAGs do not form, likely due to a lack of environmental stressors. However, all *ex ovo* fluorescent labels were accounted for, with the exception of the two oldest individuals who were missing a label due to remodeling. Furthermore, when two fluorescent injections were given 21-22 days apart, the labels could not be differentiated from each other due to the new bone not being deposited at a quantifiable level. Injections given to embryos *in ovo* were visible in all individuals at all ages in all bones, with the exception of the tibia.

Overall, the tibia in leopard geckos is the least reliable bone element to use for bone histology and skeletochronology studies because of a higher rate of remodeling. Examination of the humerus, radius, and fibula are recommended for the most accurate results since they show the lowest levels of remodeling. This research highlights, as in other extinct and extant animals, that bone elements remodel differently, and as such, it is recommended to study more than one bone element from multiple individuals for a complete picture of overall growth.

Funding Sources Funding was provided by a University of Manitoba Undergraduate Research Award to Sierra C. Schlieff and an NSERC-DG and CFI-JELF to Dr. Kirstin Brink.

Romer Prize Session (Thursday, November 3, 2022, 8:00 AM)

SINKING TEETH INTO ONTOGENY: DENTAL MICROWEAR TEXTURAL ANALYSIS QUANTIFIES DIETARY NICHE PARTITIONING BETWEEN AND WITHIN TYRANNOSAURS

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Given the immense separation of body size between juvenile and adult tyrannosaurs it is likely they consumed different prey. However, reconstructing the dietary niche of these non-analogous carnivores is challenging, as their dentition provides relatively few clues to specialized dietary ecology. While dental microwear texture analysis (DMTA) has been effective in characterizing generalized diet in modern reptiles, recent studies fall short of identifying specific dietary components that contribute to dental microwear. Further, as inferences of tyrannosaur diet from extant reptiles may be limited due to reptiles' relatively small body size, and inferences from oft-studied carnivorous mammals may be misleading due to differences in form and function, it is necessary to calibrate interpretations of DMTA across these taxa before they can be applied to tyrannosaurs. Here we examine patterns of both DMTA and International Organization for Standardization

(ISO) texture analysis within and between mammalian and reptilian carnivores and identify specific dietary components that correlate to dental microwear in each. We then utilize these results to interpret the dental microwear of in-situ teeth of four tyrannosaur genera at three age classes (juvenile, subadult and adult) between and within each genus through ontogeny. We find significant differences in dental wear through ontogeny within all genera, and among multiple age classes between genera, indicating ontogenetic and taxonomic dietary separation. Specifically, our results indicate adult and juvenile tyrannosaurs consumed brittle foods with relatively little bone interaction, possibly indicative of consuming thick integument and flesh mostly whole. Conversely, sub-adult tyrannosaurs, particularly *Tyrannosaurus* consumed more malleable foods, with high instance of durophagy, potentially through the utilization of defleshed carcasses as a dietary supplement. Finally, we find significant differences in dental wear between multiple age classes of co-occurring tyrannosaurs, a possible avenue of competition avoidance within these genera.

Technical Session - New Methods (Thursday, November 3, 2022, 10:15 AM)

BENCHTOP MICRO-X-RAY FLUORESCENCE: AN EXCITING TOOL FOR TAXONOMIC PURPOSES WITHIN PALEONTOLOGY

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The earliest Eocene (Ypresian) Fur Formation of northwestern Jutland, Denmark is a Konservat-Lagerstätte, world-renowned for its exceptionally well-preserved fossil fauna, including fossil pigments, plants, insects, sea turtles, birds and fishes. It contains a wealth of exquisitely preserved, often complete articulated fish fossils. In terms of both abundance and diversity, bony fishes are one of the most well-represented groups of macrofossils of the Fur Formation, and thousands of fossil fish specimens are housed in museum's collections across Denmark. Nevertheless, it is also the fossil group with the least publications from the formation, and only a few taxonomic studies have been realized to date. None of these has dealt with the most common fishes the Fur Formation. In paleoichthyology, anatomical descriptions necessary for taxonomic identification of fossil fishes requires specialist knowledge and often still relies solely on traditional studies using conventional stereomicroscopy. The quality of preservation, sedimentary matrix, and type of fossil preparation (if any) are all factors affecting the presence and accessibility of meristic, morphometric and anatomical features useful for systematic purposes. Micro-X-ray fluorescence (μ XRF) is becoming a popular tool in different fields of Earth sciences, but the full potential of this technology, especially within palaeontology, remains to be explored. This is the first comprehensive study, which applies non-destructive benchtop μ XRF-element mapping as a novel

tool to expose fossil fish anatomical features, which are commonly not accessible by means of traditional approaches. The advantages of the μ XRF-element mapping provide: 1) precise information on anatomical structures, which are normally problematic or impossible to discern; 2) critical and precise images for determination of anatomical characters directly relevant for taxonomic and phylogenetic studies; 3) detailed and precise images of squamation patterns and body parts hidden by overlying anatomical structures or thin layers of sediments. This study is predominantly based on fish fossil from the Eocene Fur Formation of northwestern Denmark, but fish fossils from the underlying Ølst Formation (Eocene, Denmark), Monte di Pesciara (Eocene, Italy), Green River Formation (Eocene, USA), and Hochberg Formation (Oligocene, France), were also studied using the μ XRF-element mapping method, yielding similar results.

Funding Sources Innovation Fund Denmark, Kulturministeriets Forskningsmidler, Dronning Margrethe and Prins Henriks Fond, Japetus Steenstrup legat, and Villum Foundation.

Romer Prize Session (Thursday, November 3, 2022, 8:00 AM)

ENDOCRANIAL SENSORY SYSTEMS REVEAL ECOMORPHOLOGICAL ADAPTATIONS TO A SECONDARILY AQUATIC LIFESTYLE IN THALATTOSUCHIAN CROCODYLOMORPHS

Schwab, Julia A.

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Major transitions into new ecosystems have occurred many times during evolutionary history and result in modifications of their bodyplan, physiology, behaviour and lifestyle. Thalattosuchian crocodylomorphs were highly specialised aquatic vertebrates from the Early Jurassic to the Early Cretaceous (ca. 191–125 Ma) that evolved from terrestrial ancestors. They were comprised of two subgroups. Teleosauroids have a gharial-like bodyplan and originated in semiaquatic environments. The metriorhynchids then modified their bauplan to an obligately pelagic lifestyle, with paddle-shaped limbs, a vertically orientated tail fluke, and a streamlined body. While these osteological changes are well understood, less is known about their cranial sensory systems, such as the bony labyrinth of the inner ear and brain endocasts. They are powerful ecological proxies that can be correlated with animal behaviour and lifestyles, and are key to understand how anatomy, morphology and physiology changed as a response to a new habitat.

I use new data from computed tomography (CT) scans of 18 extinct and 14 extant crocodylomorph species to identify morphological differences in their brain endocasts and bony labyrinths. Multivariate statistical analysis (GMM) and phylogenetic comparative methods reveal that both sensory systems developed a unique morphology when

metriorhynchids ventured into the open ocean. Pelagic metriorhynchids had a distinct endocast shape compared to the semiaquatic *Pelagosaurus typus*, teleosaurids and modern crocodylians. The most distinguishing feature of the pelagic endocast is smaller optic lobes, suggesting that metriorhynchids might have relied less on vision than previously suggested. Additionally, three distinct bony labyrinth morphologies were observed in crocodylomorphs based on their habitat preferences: terrestrial, semiaquatic and pelagic. Pelagic metriorhynchids have labyrinths that are more compact, dorsoventrally shorter, with thicker semicircular canal diameters and a larger vestibule compared to the terrestrial ones. These modifications might have helped metriorhynchids achieve more complex body movements in their ocean environment, but also indicates that thalattosuchians changed their body plan before fully adapting their sensory systems for their new ocean habitat. These results demonstrate that endocranial sensory systems can provide unique insights into thalattosuchians transition when they adapted to their ocean realm.

Funding Sources Funding Source: This project is supported by a Leverhulme Trust Research Project grant (RPG-2017-167).

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

COMPARING DIETS OF THE MESONYCHID DISSACUS AND BLACK-BACKED JACKAL CANIS MESOMELAS USING DENTAL MICROWEAR TEXTURE ANALYSIS

Schwartz, Andrew F.¹, DeSantis, Larisa R.², Mueller, Elsa³, Scott, Robert¹

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Dissacus was a very successful genus of mesonychid that was dispersed across the Holarctic from the Paleocene to the early Eocene. It possessed an unexpected combination of features including a flexible elbow joint, hooves, and a faunivorous dentition. This mosaic of ungulate and carnivoran characteristics complicates the understanding of its ecological niche. Various other mesonychids have been typically reconstructed as mesocarnivores, bone-crushing scavengers, and hypocarnivorous omnivores. With body mass estimates ranging from 9-21 kilograms, species of *Dissacus* compare favorably to the extant black-backed jackal (*Canis mesomelas*). Besides a similar body size, *C. mesomelas* may make a suitable modern proxy for *Dissacus* due to their similar body proportions and status as small faunivores living in the shadows of much larger carnivorous animals in their respective habitats. We analyzed shearing facets from the mandibular molars of both taxa using white-light confocal

profilometry. Results show significant differences in dental microwear textures, including higher *epLsar* and lower *Asfc* values in *Dissacus*. These data suggest that *Dissacus* likely consumed tougher and less-brittle objects than those consumed by *C. mesomelas*. This pattern may be consistent with *Dissacus* consuming more flesh, while also encountering less bone during chewing. Therefore, *Dissacus* likely occupied a niche that differed from the omnivorous-generalist niche filled by the modern black-backed jackal.

Funding Sources Center for Human Evolutionary Studies (CHES), Rutgers University

Virtual Posters

A MAASTRICHTIAN HADROSAUR FROM THE RIPLEY FORMATION, SOUTHWESTERN GEORGIA, USA

Schwimmer, David

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Dinosaur remains in the Late Cretaceous of the Southeastern United States (North Carolina to Missouri) are relatively widespread, but also poorly preserved in predominantly marine deposits. In addition, most Southeastern dinosaur fossils, including all identifiable to species, have been found in early to mid-Late Cretaceous deposits (Santonian and Campanian ages) and are rare in the regional Maastrichtian units. None have been previously reported from the Maastrichtian in western Georgia.

An isolated juvenile hadrosaur hind limb element was recently discovered by Walker Wilson in the uppermost Ripley Formation in Stewart County, western Georgia. The specimen is poorly preserved, but comprises the shaft, most of the presumed proximal head, and a portion of the presumed distal end. The following is based on the initial diagnosis that the bone is a left femur. The proximal trochanters are preserved sufficiently to allow estimates of the original width at 168 mm. There is a projection on the shaft approximately one-third distal to the head, probably an eroded remnant of the fourth trochanter. The total length as preserved is 580 mm.

The specimen is not taxonomically determinable, other than based on characteristic hadrosauroid femoral shaft proportions. The occurrence is however notable because it was found *in situ* within 4 meters of a distinctive formational boundary between the upper Ripley and basal Providence Formations. The stratigraphic correlations and relative age of this boundary are well constrained to the lower-middle Maastrichtian. This firm stratigraphic position contrasts with other Maastrichtian hadrosaur occurrences in the American Southeast which lack concisely determined stratigraphic positions. This fibular specimen is the geologically youngest dinosaur fossil from Georgia and among the rare Maastrichtian dinosaur fossils in the Southeast.

Technical Session 16: Hoofed Mammals (Saturday, November 5, 2022, 8:00 AM)

EURYGNATHOHIPPUS FROM LEDI-GERARU, AFAR DEPRESSION, ETHIOPIA

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The Ledi-Geraru Research Site is located between the Awash and Ledi River basins in northeastern Ethiopia, east and north of the famed Hadar hominin site. Fluvio-lacustrine sedimentary deposits at Ledi-Geraru date between 2.84 and 2.58 Ma, and have yielded the earliest record of the genus *Homo* along with an abundant vertebrate fauna. Fossils from the site are plentiful if often fragmentary, and include numerous remains of hipparionine horses belonging to the endemic African genus *Eurygnathohippus*. Equid craniodental remains consist largely of maxillary and mandibular fragments and isolated teeth, while postcrania are primarily distal limb elements. Two species, the larger *E. hasumense* and the smaller *E. afarensis*, appear to be represented in the assemblage.

Previous studies of hipparionine horses from the older Hadar site proposed a possible reduction in body size near the top of the available stratigraphic section, based upon a small metacarpal III from the Kada Hadar 3 member of the Hadar Formation (c. 3.0 Ma). Fossils of *Eurygnathohippus* from Ledi-Geraru site demonstrate that both large and small forms were present in these younger sediments. Although the overall vertebrate fossil record from the region suggests faunal turnover related to the spread of more open and probably arid habitats, *Eurygnathohippus* does not appear to have uniformly responded to these environmental shifts with significant body size reduction.

Funding Sources NSF Grant BCS-1157351

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

THE DEVELOPMENT OF MOLAR COMPLEXITY AND THE EVOLUTION OF THE TRIBOSPHENIC MOLAR

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The evolution of the tribosphenic molar is a key mammalian innovation as it allowed for more efficient oral processing of food through the combination of shearing and crushing during a two-phased power stroke and the ability to fully exploit transverse mandibular movements. Although an increase in molar complexity (i.e., the addition of cusps and shearing faces) is a major feature of the tribosphenic molar compared to earlier forms, the developmental mechanisms controlling for this increase are unclear. Recently, it was suggested that the Inhibitory Cascade Model (ICM) explains the development of molar complexity among living mammals. The ICM postulates that molar morphogenesis follows a cascading pattern, where a balance of activator/inhibitor signaling activity in earlier developing teeth affects the development of later teeth and produces a linear relationship in the complexity of the molar row. Therefore, it is possible that it was this mechanism that provided the genetic framework for the development of tribosphenic molars. Here, we examined molar complexity and the ICM in a sample of pretribosphenic and tribosphenic mammals spanning the Early-Jurassic through Late Cretaceous.

We included 9 taxa that represent key morphotypes in the evolution of the tribosphenic molar such as the mammaliaform *Morganucodon*, the dryolestid *Laolestes*, the amphitheriid *Palaeoxonodon*, the zatherian *Permaus*, and the tribosphenid *Kielantherium*. We measured lower molar complexity using a dental topographic metric known as orientation patch count, which quantifies the complexity of a surface.

Our results suggest that more plesiomorphic taxa such as *Morganucodon* ($R^2 = 0.187$) and *Laolestes* ($R^2 = 0.387$) do not follow the predictions of the ICM. However, derived taxa close to the base of Tribosphenida, like *Palaeoxonodon* ($R^2 = 0.912$), *Permaus* ($R^2 = 0.994$), and all subsequent taxa, follow the predictions of the ICM in that their molar complexity is linear from M1 to M3 ($R^2 \geq 0.900$).

Our findings suggest that inhibitory dynamics may have evolved to provide a simple control for the evolution/development of molar complexity in early tribosphenic mammals, where selection needs only act upon the first molar to change the entire molar row. It is the ICM that may have provided the genetic control for changing molar complexity in the evolution of tribospheny and may have provided the means for mammalian molars to rapidly diversify into the varied forms characterizing mammals today.

Funding Sources Funding was provided to KRS by the Kalbfleisch Postdoctoral Fellowship, Richard Gilder Graduate School, American Museum of Natural History.

Virtual Posters

DIETARY HABITS AND TUSK USAGE OF NORTH AMERICAN SHOVEL-TUSKED GOMPHOTHERES: EVIDENCE FROM MICROWEAR OF MOLARS AND UPPER AND LOWER TUSKS

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The paleodiet of the North American shovel-tusked gomphotheres (*Amebelodon floridanus*, *Konobelodon britti*, and *Serbelodon barbourensis*) was assessed via molar microwear analysis of molar dental enamel and compared to a large database of both extant proboscideans and ungulates. Results were also compared to molar microwear results of another shovel-tusked gomphotheres – *Platybelodon grangeri* from the Linxia Basin of China. Results show a consistent browsing signal in *A. floridanus*, *K. britti* and *S. barbourensis* and in *P. grangeri*. These results are more similar to those of the extant *Loxodonta cyclotis* than to *Loxodonta africana* or *Elephas maximus*. Scratch width scores are high indicating the ingestion of some coarse vegetation, most likely bark and twigs although extant elephants have a wider variety of scratch textures than the North American and Chinese shovel-tuskers indicating a wider variety of food substances ingested (i.e., some grass as well as leaves and bark). Large pitting and gouging is lower in the shovel-tusked forms compared to extant elephants indicating the occupation of more open habits in the latter, although *S. barbourensis* has the highest large pitting and gouging of the shovel-tusked fossil forms studied. Both upper and lower tusks were examined for both macroscopic and stereomicroscopic scratch patterns in the North American shovel-tusked forms. Results indicate a variety of scratch patterns indicating a variation in tusk usage behavior. Some *Serbelodon* and *Konobelodon* mandibular tusks exhibited digging behavior, although *Konobelodon* digging behavior was much more common and obvious, whereas *Amebelodon* and *Platybelodon* mandibular tusks did not exhibit digging behavior and were more likely used for stripping and scraping in the former and cutting in the latter. Upper tusk usage varied in the North American species with all three species exhibiting scraping and/or cutting behavior. Results indicate that shovel-tusked gomphotheres occupied a relatively narrow dietary niche but exhibited a variety of strategies to obtain the vegetation that they consumed via their tusks.

Technical Session 3: Marine Reptiles (Wednesday, November 2, 2022, 8:00 AM)

INTRA-SKELETAL VARIABILITY IN PHOSPHATE OXYGEN ISOTOPE COMPOSITION OF MARINE VERTEBRATES AS A TOOL TO TRACK REGIONAL HETEROTHERMIES IN MESOZOIC MARINE REPTILES

Séon, Nicolas¹, Vincent, Peggy¹, Delsett, Lene L.², Roberts, Aubrey J.³, Suan, Guillaume⁴, Lécuyer, Christophe⁴, Fourel, François⁵, Hurum, Jørn H.³, Charbonnier, Sylvain¹, Amiot, Romain⁴

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Marine vertebrates use various strategies to regulate their body temperature, which can result in local temperature variations. Many extant marine endothermic organisms let the temperature of some areas of the body drop to limit heat loss, whereas some ectotherms are able to generate heat locally to improve visual acuity in cold environment, swim faster or migrate over longer distances. These strategies lead to temperature heterogeneities called regional heterothermies that can be measured on extant organisms using thermometry. Such heterogeneities are however poorly constrained in extinct marine vertebrates.

In this study, we have analyzed the oxygen isotope composition of phosphatic skeletal elements ($\delta^{18}\text{O}_p$) of five extant regional heterotherms (dolphins, swordfish and Atlantic bluefin tuna) to assess whether regional heterothermies can be monitored using their $\delta^{18}\text{O}_p$ values. The results indicate a consistent link between $\delta^{18}\text{O}_p$ variations and temperature heterogeneities recorded by classical methods and demonstrate the robustness of this method to track regional heterothermies using skeletal remains. We will also present preliminary intra-skeletal $\delta^{18}\text{O}_p$ data obtained on Mesozoic ichthyosaurs and plesiosaurs and discuss their implications for the thermophysiology and ecology of these large extinct marine predators that dominated the oceans during the Mesozoic.

Funding Sources This work was financially supported by the ANR-18-CE31-0020 “Oxymore” program.

Colbert Prize Session

FIRST FORELIMB RECONSTRUCTION AND RANGE OF MOTION ASSESSMENT OF THE LATE CRETACEOUS DINOSAUR *TROODON FORMOSUS*

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Troodon formosus is a theropod dinosaur from the Late Cretaceous of North America primarily known from fragmentary fossil material. 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. 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 by leveraging recent digital modelling technology to create the first forelimb reconstruction and ROM estimate for *Troodon*.

To overcome preservational limitations, we digitally combine surface scans from multiple incomplete, but associated *Troodon* fossils housed in the Museum of the Rockies to reconstruct a complete forelimb. From this model, we utilize both digital articulation in Maya and physical articulation ROM methods to compare assumptions in digital models with physical limitations observed in 3D printouts of the reconstructed forelimb. In both models we utilize previously published data to estimate and account for the *in vivo* presence of cartilage at each joint. ROM is estimated from the maximum angle of allowed motion at each joint until bone-on-bone contact occurs. Comparison with other troodontids sheds light on the physiological, ecological, and behavioral diversity within this clade. These results elucidate the foraging and reproductive behavior of *Troodon* and have important implications for understanding the evolution of modern avian reproductive behavior and the dinosaur-bird transition.

Funding Sources Jack Horner Paleontology Scholarship, Departmental Scholarship Montana State University School of Earth Sciences, Paleontology Society Scholarship

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

AN UNUSUAL METHOD FOR FOSSIL CONSERVATION EFFORT WHILE MAKING PALAEOONTOLOGICAL FIELD EXPERIENCES MORE SUSTAINABLE AND INCLUSIVE ALONG THE BAY OF FUNDY, NOVA SCOTIA, CANADA

Serratos, Danielle J.

Fundy Geological Museum, Parrsboro, Nova Scotia, Canada

Smaller rural science museums often struggle with gathering the needed resources each year to have a successful field season. Lack of adequate funding affects the ability to secure the necessary staff and equipment needed to conduct research, while museums in remote locations often lack amenities desirable to a potential workforce. The Fundy Geo Museum is a small, provincial museum that is two hours from city amenities but sits along the coast of the world-famous Bay of Fundy, home to the world's highest tides. Field sites along the shoreline surrounding the Museum are where Canada's oldest dinosaurs are found and the flora, fauna, and ichnofauna of the Triassic-Jurassic boundary are stunningly preserved. Due to the tidal nature of these areas, field sites are inaccessible for

six hours, twice per day, every day. The shoreline along the Bay of Fundy is under constant erosion, which is a double-edged sword as they regularly expose fossil material which are then subject to the tides, cliff collapse, and storms along the coast. This raises the question, how does an underfunded museum in a remote location collect and conserve this steady supply of fossil material before they are lost to the sea? The Fundy Geo Museum has increased our observation and collection of fossils by engaging citizen scientists to collaborate with our efforts in numerous ways, including paid opportunities, volunteer efforts, and hands-on educational programming. The most unique experience we offer is the Fossils on Horseback half-day excursion, where guests ride to and from the field site on horseback and sieve through 200-million-year-old sandstone for fossil remains. Other programs include weekly trips to active field sites that are open to the public as well as private group tours. Local community members and research collaborators often assist in summer field activities, but the grade-school outreach field excursions that target underrepresented students in STEM is the most rewarding field work we accomplish each year. All these efforts combined have significantly increased the amount of time spent assessing and excavating fossil materials at our field sites while maintaining best practices for fossil collecting. This has resulted in numerous scientific finds, peer-reviewed publications, considerable revenue for the Museum, community goodwill in terms of promoting local tourism, and has created increased opportunities for the public to contribute to modern scientific discoveries.

Technical Session 3: Marine Reptiles (Wednesday, November 2, 2022, 8:00 AM)

VENOM-ASSISTED FEEDING IN MOSASAURS IMPLIED BY COMPARATIVE MANDIBULAR BIOMECHANICS

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Mosasaur are extinct marine squamates that evolved from terrestrial ancestors during the Late Cretaceous, filling diverse feeding niches in oceans worldwide. Mosasaur are distinguished from most other marine tetrapods by their kinetic mandibles, considered to represent an adaptation for consuming large prey (macrophagy). We used comparative beam theory analysis to determine relative strengths of 15 mosasaur mandibles for comparison alongside 86 other species of squamates and aquatic predators. We also used osteological traits associated with inter- and intramandibular joints to proxy for mandibular kinesis in a sample of venomous and nonvenomous lizards to examine relationships between kinetic jaws and feeding methods.

Using principal component analysis (PCA), we found that aquatic tetrapods form a spectrum of jaw strengths from micro- to macrophagous predators, within which all mosasaurs, regardless of evidence for macrophagy, place with microphagous taxa. Although macrophagous and durophagous mosasaurs showed higher jaw strengths than mosasaur taxa adapted for hunting small fish and invertebrates, the jaw strengths of mosasaurs do not show the same disparity across inferred feeding regimes as observed in other clades of aquatic predators. Instead, we find mosasaurs grouping with venomous lizards, small porpoises, and baleen whales due to relatively weak anterior and middle beam force profiles.

Kinetic mandibles were found to be reliable predictors for alternative prey capture methods (e.g., envenomation, constriction) in extant squamates. In particular, the coronoid bone is modified to immobilize the intramandibular joint in nonvenomous lizards, including those with secondary loss of envenomation feeding strategies (e.g., iguanas). Similarly, mosasaur-like intermandibular kinesis allows macrostomy in mysticetes that have adopted baleen feeding over biting for prey capture. We propose an evolutionary trade-off between bite force and macrostomy, wherein mandibular kinesis evolves when the role of bite force in prey capture is reduced. Mosasaur mandibles are flexible but structurally weak, indicating a reduced role of bite force in prey capture. Given the lack of adaptations for filter feeding or constriction, a well-established phylogenetic position of mosasaurs within the ancestrally venomous squamate clade Toxicofera (iguanians, anguimorph lizards, snakes) supports venomous feeding as the null hypothesis to explain their functionally plesiomorphic jaws.

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

THE PHYLOGENY OF PALEOCENE MAMMALS AND THE EVOLUTION OF PLACENTALIA

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Resolving the phylogenetic relationships among Paleocene mammals has been a longstanding goal in paleontology. Constructing an accurate and comprehensive phylogeny for Paleocene mammals is a worthwhile objective in itself, but it also provides a framework on which we can better understand the origin of placental mammals and the evolutionary processes underlying the diversification of mammals before, during, and after the end-Cretaceous mass extinction. More recently, a robust Palaeocene mammal phylogeny has become a much-coveted tool for reconciling discrepancies between morphological and molecular evidence for the phylogeny and diversification of Placentalia.

Here, we present a novel phylogenetic dataset to test hypotheses regarding Paleocene mammal phylogeny and the origin and diversification of Placentalia. To date, our matrix combines phenomic data for 36 extant mammal species and 107 fossil species scored for 2540 morphological characters alongside 26 genes sequenced for 47 species. We utilized a reductive morphological scoring strategy in order to minimise assumptions and test hypotheses on homology. Multiple sequence alignments were performed in MEGA-X for each gene. We then analysed the data using Bayesian methods and explored the effects of different approaches.

Relaxed clock analyses using a molecular constraint and an FBD prior are congruent with the diversification of many extant orders prior to the K-Pg boundary. Relaxed clocked total-evidence analyses (morphology and molecules) using an FBD prior resulted in older ages of diversification than those estimated by our relaxed clock molecular constraint model and previous molecular studies. Within Placentalia, our phylogenies provide support for the divergence of Atlantogenata (Afrotheria and Xenarthra) from Boreoeutheria (Euarchontoglires and Laurasiatheria). Among the Paleocene taxa, 'condylarths' are distributed along the base of Laurasiatheria with members of 'Arctocyonidae' recovered as sister taxa to Artiodactyla; enigmatic groups such as Pantodonta and Taeniodonta are recovered as crown placentals whereas Leptictida is not. Our Paleocene mammal phylogeny is a critical step toward better understanding placental mammal evolution. Ultimately, this work will facilitate the investigation of fundamental questions previously encumbered by the lack of a well-resolved phylogeny.

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Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

NEW GEOGRAPHIC AND STRATIGRAPHIC OCCURRENCES OF THE ENIGMATIC EXTINCT LAMNIFORM SHARK, *MEGALOLAMNA* (LAMNIFORMES: OTODONTIDAE), FROM THE EASTERN USA

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Megalolamna is an extinct lamniform shark genus that is known from Miocene marine deposits and is represented by a single species, *M. paradoxodon*. Although its dental morphology suggests that the taxon belongs to the family

Otodontidae Glikman, the species name (*paradoxodon*) denotes its paradoxical occurrence marked by geologically confined (Aquitanian-Burdigalian) but geographically wide distributions with an uncertain phylogenetic affinity within the otodontid clade. Previous records of the species are from the following seven Miocene localities: the Pungo River Formation of North Carolina, USA; Jewett Sand in California, USA, Uitpa Formation in Colombia, Dos Bocas Formation of Ecuador, the Chilcatay Formation of Peru; the Oi Formation in Mie Prefecture, Japan; and the O'oshimojo Formation in Nagano Prefecture, Japan. In this study, we report three new specimens of *Megalolamna* collected from the eastern USA. Two specimens come from the lower Miocene Calvert Formation of Maryland (CMM-V-10270 and V-10306: Calvert Marine Museum, Maryland, USA), whereas one comes from the upper Oligocene Chandler Bridge Formation in South Carolina (CCNHM 6052: College of Charleston's Mace Brown Museum of Natural History, South Carolina). They offer new anatomical information, where, for example, CMM-V-10270 represents a tooth from the most distal dentitional position described to date for *Megalolamna*, and CCNHM 6052 exhibits fine serrations along the base of the mesial cutting edge and mesial lateral cusplet as well as a well-marked 'bourlette' (a thin enameloid layer) on the lingual tooth neck. Although the presence of serrations may represent individual morphological variation, the presence of a bourlette in CCNHM 6052 may suggest that the characteristic is plesiomorphic in the clade where the lack of bourlette in some previously described specimens of *Megalolamna* may simply represent loss due to taphonomic abrasion. Whereas the specimens from the Calvert Formation represent the northernmost occurrence for the taxon, the occurrence from the Chandler Bridge Formation represents geologically the oldest record for *Megalolamna*, demonstrating that the enigmatic genus has its origin in the Paleogene no later than 23.5 Ma.

Preparators' Session (Thursday, November 3, 2022, 8:00 AM)

PLASTER FIELD JACKETS USING AIR FILTER MEDIA: AN ALTERNATIVE TO TRADITIONAL BURLAP AND PLASTER JACKETS

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Traditional plaster field jackets using plaster and burlap were developed by paleontologists in the late 19th century, and the same technique is still widely used today. Occasionally the plastering process fails due to improper measuring and/or mixing and often wastes plaster. Poor distribution of burlap across the specimen increases the risk of failure as well.

In the early 2000's, an air filter media made of polyester, which is used in HVAC systems and sold in bulk rolls of varying sizes, was proposed as an alternative material to burlap on the preparators' listserv. After nearly 20 years of

experiments and field use, the Field Museum team has achieved a quick and effective method of making plaster field jackets using 1" thick filter media. In this method, one square foot of filter media requires plaster mixed with 1 qt of water. Five steps are required to make a successful filter media plaster jacket; 1) prepare a block containing fossils by isolating and undercutting the block, filling large gaps and cracks with mud or paper, and covering it with a separator such as wet paper towel, 2) overlay uncut filter media with the tacky side facing down, mark a line for cutting and orienting the filter media, then cut it with a pair of scissors, 3) measure water according to the size of the filter media, disperse the plaster evenly onto water, and let soak undisturbed for 3 minutes, then mix continuously for 3 minutes, 4) saturate the filter media with the plaster mixture, and 5) place it on the block when the plaster mixture is viscous, rub and squeeze the surface to remove air pockets, and add remaining plaster to smoothen the surface.

The compression strength of the casting plaster is up to 1200 psi after one hour of setting and 2400 psi after complete drying, and a single layer of filter media with casting plaster is equivalent to 3 to 4 layers of burlap with plaster, but it is uniform in thickness. In order to achieve the maximum strength, the proper ratio of water-to-plaster and the timed soaking and mixing technique described above should be used. Minimal plaster is wasted with this method because all the components, the filter media, water, and plaster, are measured. The filter media plaster jacket is a quick one-piece wrapping technique that is an excellent alternative to the traditional plaster and burlap method.

Technical Session 14: Squamates & Turtles (Friday, November 4, 2022, 1:45 PM)

NO TEETH, NO PROBLEM: ORIENTATION PATCH COUNT PREDICTS DIET IN TURTLES

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Orientation patch count rotated (OPCr) facilitates quantitative examination of the complexity of an animal's feeding surface, and has previously been used to analyze how tooth complexity relates to diet in squamates, crocodylians, and mammals. These studies show a strong correlation, with low dental complexity indicative of faunivory and high dental complexity indicative of herbivory. However, dietary prediction using OPCr has not been performed on the feeding structures of edentulous (toothless) taxa. Here we examine the relationship between complexity of the palatal triturating surface and diet in extant turtles. After using OPCr to analyze fifty five specimens, forty two of which preserve both a skull and keratinous

rhamphotheca, we found that edentulous triturating surfaces show a relationship between diet and complexity similar to the relationship seen in teeth: carnivorous turtles have significantly lower OPCr values than herbivorous, omnivorous, or durophagous turtles ($p < 0.05$). Finally, we note the presence or absence of an alveolar ridge, a distinct raised portion of the maxilla and sometimes the premaxilla that varies in morphology from a serrated line running medially along each side of the triturating surface to a bulge with pointed protrusions. This structure is present, but variable, in all herbivores, and seemingly convergently evolved in Cheloniidae, Emydidae, and Testudinidae. Non-herbivores in the dataset (omnivorous *Trachemys elegans* and carnivorous *Eretmochelys imbricata*) with an alveolar ridge are nested within ancestrally herbivorous clades, and the lack of a ridge in at least two durophagous lineages likely represent evolutionary losses. Despite its apparent relationship to herbivory in turtles, very little information exists on this structure. Further research is needed to understand the extent to which phylogeny, ontogeny, and diet impact the presence and structure of the alveolar ridge.

Beyond confirming that OPCr values can predict diet in edentulous taxa, we also found no significant difference in complexity between keratin and the underlying bone. Therefore bone can be used to predict diet when the keratinous sheath is absent, as is typical in fossil taxa.

Funding Sources Field Museum of Natural History, Idaho State University, Idaho Museum of Natural History

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

TUSK GROWTH AND PRESERVATIONAL SETTING OF AN LGM MAMMOTH AT THE MARGIN OF THE ICE SHEET

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In 2018, a partial skull of a large male mammoth was found in a gravel quarry in St. Paul, Minnesota. We originally sought to include this specimen in ongoing work on male mammoth life histories, but here we address mainly questions related to its unique preservation. Radiocarbon dating returned an age of $27,280 \pm 200$ cal yr bp—during or slightly before the last glacial maximum (LGM) when this area was near the ice margin. The partial skull includes the upper third molars along with left maxillary sinus cavities and the proximal half of the left tusk. Morphology of the molars, geologic age, and geography are consistent with this specimen belonging to *Mammuthus 'jeffersonii'*, thought to be a hybrid of *M. primigenius* and *M. columbi*. The tusk is broken transversely

at around 1.35 m from its proximal end, still in place in the alveolus, and protrudes about 0.75 m from the alveolar margin to its broken tip. The exposed pulp cavity of the tusk contains sediment, including both gravel-size clasts, consistent with deposition from a fluvial system, and a finer-grained sediment matrix containing iron sulfide minerals. This sediment is cemented to the upper-right side of the pulp cavity, indicating that the animal's skull was preserved with its anterodorsal aspect horizontal and oriented downward. Pyrite and other iron sulfide minerals are uncommon among mammoth remains, and their origin may be groundwater and surrounding sediments. The iron sulfide is concentrated along the pulp cavity and external surface of the tusk but not found on similar bone, tooth, or sinus surfaces. The co-occurrence of preserved collagen in bone and iron sulfide minerals in/on the tusk posed a challenge for specimen management. We opted to maintain a low relative humidity to reduce acidic products of sulfide oxidation at the cost of some shrinking and fracturing of the specimen. We used minimally intrusive sample collection, CT scans, and photogrammetry to document parts of this mammoth's life, including 13 years with annual tusk increment thicknesses of about 5–6 mm, and to describe its season of death based on thin section microscopy and carbonate isotopes. This specimen shows that mammoths could survive even near the ice margin, and allows us to highlight analyses that help elucidate cause of death based on season of death and other aspects of life history.

Technical Session 11: Synapsida (Friday, November 4, 2022, 8:00 AM)

THE FOSSIL RECORD OF THE TRIASSIC FREMOUW FORMATION (ANTARCTICA): HISTORY OF COLLECTING AND A NEW BAURIAMORPH (THERAPSIDA: THEROCEPHALIA)

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The rarity of expeditionary work in the Transantarctic Mountains, coupled with the inaccessibility of the region to non-US Antarctic Program collectors, means that a near complete history of the development of the Fremouw Formation's vertebrate fossil record can be reconstructed. Since the first discovery of a fossil tetrapod in 1967, nine seasons of fieldwork totaling approximately 50 weeks have recovered over 1400 specimens from the informally

recognized lower, middle, and upper members of the Fremouw Formation, with the lower member yielding the bulk of the material with sufficient stratigraphic resolution (>80%). Snow, ice, and dolerite scree limit available outcrop and contribute to the majority (~84%) of vertebrate fossils hailing from nine localities, with just three named localities producing all ~200 fossils from the upper Fremouw. Fifteen genera and eight higher level taxa (e.g., Akidnognathidae indet.) have been recognized from the Lower Triassic (lower and middle Fremouw). Although only a handful of identifiable specimens have been recovered from the middle Fremouw, the composition of this tetrapod assemblage points to its correlation with the upper part of the *Lystrosaurus declivis* Assemblage Zone of South Africa. Four genera and six indeterminate higher taxa have been recognized from the Middle Triassic (upper Fremouw). Overall, about half of the fossils identified from the Fremouw Formation are therapsids, with temnospondyls and reptiles splitting the other half. 'Fish' fossils are extremely rare. However, these proportions must be considered tentative, as unidentified fossils currently comprise 60% of museum collections.

Among the specimens collected in 2017/18 from the middle Fremouw Formation is the most complete skull of a therocephalian therapsid recovered from Antarctica to date. It preserves a unique dental formula, complete secondary palate formed by the maxilla, sagittal crest with a slit-like parietal foramen, long, low dentary, and reduced upper and lower antecanine tooth counts, suggesting a relatively derived position within Baurioidea. The results of an updated cladistic analysis suggest a sister taxon relationship of the new taxon with the clade including *Nothogomphodon*, *Ordosiodon*, and Bauriidae. We recognize the therocephalian as a third endemic species in the Lower Triassic of Antarctica, along with *Antarctanax shackletoni* and *Kombuisia antarctica*, suggesting geographically complex recovery to the Permo-Triassic extinction.

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Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

SPECIMEN-LEVEL CLADISTIC ANALYSES OF GEOMETRIC MORPHOMETRIC CONFIGURATIONS: AN EXPERIMENT USING NEOGENE-QUATERNARY EQUID PREMOLARS

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Most geometric morphometric (GM) studies of interspecific and intraspecific variation in mammalian dentition employ nonphylogenetic ordination methods, such as principal

component analysis (PCA). To our knowledge, there are no interspecific cladistic analyses of GM dental data such that each specimen is coded as a separate operational taxonomic unit (OTU).

We investigated phylogenetic signal in GM dental data by expanding a previously published dataset of equid postcanine dentition, focusing on middle-late Pleistocene North American *Equus*. As of May 2022, we have collected two 2D occlusal configurations: 24 landmarks from 158 upper premolars (P³⁻⁴), and 50 landmarks from 142 lower premolars (P₃₋₄). We sampled 2 extant *Equus* species (*E. asinus*, *E. quagga*), 10 Plio-Pleistocene species (*E. bautistensis*, *E. cedralensis*, *E. conversidens*, *E. francisci*, *E. idahoensis*, *E. nalaikhaensis*, *E. lambei*, *E. mexicanus*, *E. scotti*, *E. simplicidens*), and the late Miocene-early Pliocene "*Dinohippus*" *mexicanus*. Using the R package *geomorph*, we aligned raw landmarks from each configuration via Procrustes superimposition (*gpagen*), then performed a PCA (*gm.prcomp*). Specimen-level maximum parsimony cladistic analyses were conducted in TNT 1.5 using standard settings for New Technology Searches, either by treating each Procrustes configuration (imported from TPS files) as one character; or by coding principal components representing the first ~75% of cumulative variance as continuous characters. Additional cladistic analyses were performed using mean Procrustes configurations and PC centroids, as well as ranges of PC scores, for each taxon. In all our most parsimonious trees (MPTs), "*D*". *mexicanus* is recovered as the outgroup to *Equus*, in accordance with our PCA scatterplots and all published cladistic analyses of craniodental and postcranial characters. None of our specimen-level cladistic analysis, regardless of coding method, recover the extinct *Equus* species as reciprocally monophyletic. MPTs have low to moderate confidence intervals and retention indices, and most nodes lack bootstrap and jackknife support, in accordance with published interspecific specimen-level phylogenies for other fossil vertebrates. We expect increased taxonomic sampling, as well as inclusion of molar GM configurations, to improve topological precision.

Although the equids sampled are selenolophodont, our techniques are applicable to mammals with more plesiomorphically tribosphenic postcanine dentition.

Technical Session 15: Theropods (Saturday, November 5, 2022, 8:00 AM)

HISTOLOGICAL ANALYSIS OF ANZU WYLIEI (DINOSAURIA, OVIRAPTOROSAURIA) REVEALS VARIATION IN ADULT BODY SIZE THROUGH TIME

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North American caenagnathids are poorly known maniraptoran theropods whose ecology, diversity, and ontogeny have been historically controversial due to a paucity of articulated or associated specimens. Some of the most

complete caenagnathid specimens from North America are partially articulated and associated skeletons of *Anzu wyliei* from the Upper Cretaceous Hell Creek Formation of South Dakota, described in 2014. These specimens provide key anatomical data to contextualize fragmentary material and clarify relationships within the clade. Here we present the first histological analysis of the holotype and referred *A. wyliei* specimens (CMNH 78000 and 78001 respectively) and compare ontogenetic status and body size with two additional *Anzu* specimens from the Hell Creek Formation of Montana (ROM 65884 and BMRP 2013.4.1).

The four sampled specimens are of nearly equivalent size, with ROM 65884 and BMRP 2013.4.1 being approximately 2-3% larger than the CMNH specimens based on either tibia length or vertebral measurements. The midshaft tibial cortices of the holotype and referred *Anzu wyliei* specimens are comprised of fibrolamellar bone with multiple lines of arrested growth (LAGs). They show decreasing LAG spacing, decreasing vascular density, and a shift from reticular-plexiform to radial vasculature toward the periosteal margin; both specimens exhibit a well-developed external fundamental system (EFS). These histological features are consistent with skeletal maturity and establish the CMNH specimens as adults that reached their maximum body size. Tibiae of ROM 65884 and BMRP 2013.4.1 have fibrolamellar bone with reticular-plexiform vasculature, multiple LAGs, and reduced vascularity toward the periosteal margin. While LAG spacing decreases in both specimens, there is no EFS and decreases in vascularity are not comparable with those of the CMNH specimens. The histological features of ROM 65884 and BMRP 2013.4.1 are inconsistent with skeletal maturity and we interpret these specimens as subadults.

Subadult status of the larger ROM and BMRP referred specimens expands the expected adult body size of *Anzu*, as these individuals would have reached a larger size at skeletal maturity than the type material. Potential explanations for this body size variation include individual variation within populations, sexual dimorphism, or increasing adult body size of *Anzu* over evolutionary time, but more data are required to assess these hypotheses.

Funding Sources NSERC Discovery Grant (RGPIN-2018-06788) to DCE, NSERC Ontario Trillium Scholarship to DJS, Jurassic Foundation Grant to DJS, AWG Chrysalis Scholarship to DJS

Technical Session 11: Synapsida (Friday, November 4, 2022, 8:00 AM)

FUNCTIONAL MORPHOLOGY REVEALS THE FEEDING MODES OF CARNIVOROUS NON-MAMMALIAN SYNAPSID AND THE EVOLUTION OF TERRESTRIAL ECOLOGICAL DYNAMICS THROUGH THE LATE PALEOZOIC

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Non-mammalian synapsids became the leading tetrapod carnivores on land during the late Paleozoic, establishing themselves as key terrestrial predators through the latest Carboniferous and producing diverse carnivore assemblages by the Late Permian. The close relatedness of synapsid carnivores within such assemblages likely generated significant competitive pressures that drove divergent feeding behaviours and prey preferences, much like in coexisting mammalian predators today. As such ecological divergences underpin evolutionary change, competition was likely an important driver of synapsid macroevolution. Differences in diet can manifest in hard anatomy, particularly the teeth and jaws, as well as overall body size. Therefore, by using morphometric and phylogenetic comparative methods to chart and assess the trophic diversity of carnivorous synapsids through the latest Carboniferous to earliest Triassic (307-251.2 Ma), we investigate the potential intensity and evolutionary impacts of competition through this interval. We identify several different functional feeding groups based on the mandibular functionality of 122 taxa, highlighting the disparity of non-mammalian synapsids, especially therapsids. Changes in the prevalence of these functional groups through time highlight clear shifts in feeding behaviour that are indicative of increasing dynamism in predator-prey interactions. We also find concurrent pulses of jaw morpho-functional diversification and size differentiation that illustrate increasing niche partitioning by carnivorous synapsids as terrestrial tetrapods and their trophic interactions became more firmly embedded on land.

Funding Sources European Research Council (Advanced Grant 788203)

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

A NEW RHYNCHOSAUROIDES FROM THE UPPERMOST PASSAIC FORMATION OF THE NEWARK BASIN AND ITS PALEOECOLOGICAL SIGNIFICANCE

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Exemplary tetrapod ichnofossils from the Uppermost Passaic Formation (Latest Rhaetian) provide direct evidence of transitional ecosystems between the end-Triassic extinction (ETE) and the beginning of the Jurassic. Presence of *Rhynchosauroides* at sites astrochronologically constrained to within 10kyr after the ETE provides a link between the phylogenetically diverse and morphologically disparate sauropsid communities of the late Triassic, and their more limited presence through the subsequent Jurassic. The new

ichnospecies of *Rhynchosauroides* differs from other members of the ichnogenera in autopod emplacement patterns and scale morphology. Quantitative measurements taken via photogrammetry provide major benefits in allowing clear morphological description, specific and rapid comparison to other ichnofossils, and differentiation from other ichnotaxa. The presence of basal lepidosaurimorph traits further calls into question placements of the ichnospecies within higher clades such as the Sphenodontia. This new *Rhynchosauroides* is relatively abundant within this short interval after the ETE, spanning at most, a few 10s of thousands of years, and is associated with abundant *Eubrontes giganteus* ichnofossils but no uniquely Triassic taxa. Its abundance here stands in stark contrast to rest of the Mesozoic and Cenozoic, through which this ichnogenus is known from only a handful of specimens, highlighting its ecologically transitional status.

Technical Session 15: Theropods (Saturday, November 5, 2022, 8:00 AM)

BITEMARKS ON THE HEADS, TRAUMAS OF THE LEGS: PALEOPATHOLOGY IN *TARBOSAURUS BATAAR* (DINOSAURIA, TYRANNOSAURIDAE) FROM THE UPPER CRETACEOUS OF MONGOLIA

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The collection of 42 specimens of the largest predator known from the Nemegt Formation (Late Cretaceous, Mongolia), *Tarbosaurus bataar*, provides an opportunity to detect abnormalities within the hypodigm. The specimens which achieved more than ~50% of the adult body size bear healed lesions on the snout bones suggesting intraspecific aggression. Several teeth of one of the fully grown individuals reveal split carinae, a traumatic or genetically conditioned abnormality. Large *Tarbosaurus* specimens show many abnormalities in the bones of the pes. We identified a bony overgrowth on the 4th metatarsal, bony spurs in the areas of tendon or ligament attachment (enthesophytes) in the proximal pedal phalanges, and unusual pits covering most of the pedal phalanges of one individual. Bitemarks on the snout surface, split carinae, and enthesophytes were previously found in tyrannosaurids indicating that other representatives of this group suffered from similar conditions. Aside of healed injuries, two half-grown individuals bear non-healed puncturing bitemarks and scratching marks indicative of predation or scavenging on their carcasses. The observed abnormalities in the *Tarbosaurus* skeletons gives us insights into the life and potential dangers of one of the largest predatory dinosaurs.

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Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

A NEW LATE TRIASSIC (NORIAN) DICYNODONT FROM THE TECOVAS FORMATION (DOCKUM GROUP) OF TEXAS, U.S.A. REVEALS HIDDEN DICYNODONT DIVERSITY AND ABUNDANCE IN LAURASIA

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The Late Triassic dicynodont record is scarce in Laurasia. All known Late Triassic Laurasian dicynodonts to date are attributable to Dicynodontia indeterminate or to Stahleckeriidae. The best represented Laurasian records come from the Norian-aged *Placerias* Quarry in the Chinle Formation, U.S.A. and partial skeletons from both the Carnian and Norian of central Europe. Study of undescribed materials ("Texas dicynodont") from the Tecovas Formation Boren Quarry (Norian; Otischalkian land vertebrate faunachron), near Post, Texas, necessitates a reappraisal of the phylogenetic diversity of North American Late Triassic dicynodonts. The material consists of numerous well-preserved cranial material and partial postcrania. Among the important phylogenetic features of the "Texas dicynodont" are: maxillary caniniform process on ventral edge anterior to antorbital margin; maxillary tusks present, visible laterally, but slender; sagittal crest tall with a steep slope angle; postorbital extends nearly the entire length of intertemporal bar; basal tubera inflated, strongly rounded so that anterior and posterior tips of the tubers curve toward each other, nearly enclosing the stapedial facet; and ratio of scapula proximal breadth relative to its length is extremely narrow (less than 0.4). A phylogenetic analysis of the "Texas dicynodont" recovers it within a monophyletic Kannemeyeriidae (Kannemeyeriiformes) in an unresolved polytomy with the Middle Triassic *Acratophorus*, *Dolichuranus*, and *Wadiasaurus*. This is unexpected as globally all identifiable Late Triassic dicynodonts fall within Stahleckeriidae. Other isolated dicynodont remains that cannot be identified beyond Kannemeyeriiformes have been recovered from seven other localities in the Tecovas Formation of Texas. This, along with previous kannemeyeriiform finds in the Chinle and Popo Agie Formations of the western U.S.A., and the Newark Supergroup of eastern North America suggest an underappreciated dicynodont abundance in North America. This combined with recent dicynodont finds in the Late Triassic of Poland and Germany shows that dicynodonts were more common in Laurasia than previously thought, though

potentially of less ecological importance than archosaur herbivores, and the “Texas dicynodont” kannemeyeriid reveals previously hidden Laurasian dicynodont diversity during this time.

Technical Session 15: Theropods (Saturday, November 5, 2022, 8:00 AM)

HARD AND SOFT TISSUE RESTORATION IN THE THERIZINOSAUR *NOTHRONYCHUS GRAFFAMI* AS IT RELATES TO A STATIC POSTURE

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Nothronychus graffami was a large therizinosaur from the Upper Cretaceous (Turonian) of the southwestern United States. We provide an updated osteology and soft tissue reconstruction, especially as it pertains to functional morphology and posture of the hindlimb. Soft non-contractile tissue inference is based on observed extracapsular ligament scars and an extant avian model.

We regard the synsacrum of *Nothronychus* as minimally taphonomically modified. There is little apparent damage in the original specimen and CT data. Little alteration is seen in associated structures, including the sacral crest and acetabulum. The pre- and post-acetabular blades exhibit lateral symmetry. The synsacrum consists of five sacral vertebrae and a single sacrocaudal with an inclined central facet such that the ventral side is longer than the dorsal. This feature would result in the tail being held oblique to the synsacrum at rest. The synsacrum was inclined posteriorly, with the pubic peduncle replacing the supra-acetabular crest as a weight-bearing structure. Such an orientation should result in increased compressive stress at this point, with an associated bony reactive sclerosis along the pubofemoral ligament and reduced stress at the ischiofemoral ligament following Wolff's Law. This general pattern is observed here. The center of mass would be anterior to the acetabulum, causing the femur to rotate nearly parallel to the vertebral column at rest. The preacetabular blade is much broader than the postacetabular blade, which can be correlated with lateral divergence of the femur in birds. The ilium of *Nothronychus* exhibits a concave structure anterodorsal to the acetabulum that compares closely to a neornithine antitrochanter. This development would be unique in non-avian theropods. As in extant birds, it would brace the femur preventing extreme femoral abduction, and transfer stress to the ilium during long-axis rotation of the femur. *Nothronychus* exhibited minimal protraction or retraction of the femur because this was limited by osseous and tendinous tissue. The broadly spaced acetabulae would have resulted in a waddling stride with a predicted wide-gauge gait. Most movement took place at the knee. We prefer a digitigrade stance, but cannot exclude a plantigrade stance as sometimes has been proposed for large therizinosauroids. No

such alteration is observed in smaller, more basal therizinosauroids, including *Falcarius*.

Technical Session 14: Squamates & Turtles (Friday, November 4, 2022, 1:45 PM)

NEW TURTLE DISCOVERIES FROM THE MENEFFEE FORMATION (CAMPANIAN), NEW MEXICO, U.S.A.

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Recent fieldwork in the Allison Member of the Menefee Formation (Fm) of the San Juan Basin, New Mexico sampled an understudied interval in the lower to middle Campanian of southern Laramidia. Previous expeditions revealed a diverse dinosaurian and crocodyliform fauna, including nodosaurid, tyrannosaurid, hadrosaurid, ceratopsian, and neosuchian taxa. New Menefee turtle discoveries of Baenidae, Helochelydridae, Trionychidae, and Adocidae provide insight into Campanian turtle evolution in southern Laramidia and inform paleoenvironmental reconstructions of the San Juan Basin.

A shell of the baenid *Scabremys ornata* was recovered with welt-like surface sculpture arranged in elongate parasagittal ridges, slight posterior scalloping, and a fifth vertebral scale that contacts the posterior margin. The presence of *S. ornata* in the Allison Member represents a stratigraphic range extension farther back into the Campanian. The stem baenid *Neurankylus baueri* is represented by a large, smooth, ovoid shell with a single cervical scale, wide subrectangular vertebral 1, extragulars separated by gulars, and absent prepleurals. The helochelyrid *Naomichelys* was recognized by small fragments with diagnostic raised tubercles.

Three trionychid taxa are present: “*Trionyx*” (*Aspideretoides robustus*) is most common and diagnosed by finer pitting that fades toward the carapace center. “*Trionyx*” (*Aspideretoides austerus*) is less abundant and has a coarser texture separated by sharp ridges and an upturned marginal carapace lip. A third taxon has even larger, widely separated pits. Finally, *Adocus* was diagnosed by surface sculpturing consisting of elongate, diamond-shaped pits arranged in rows of 4-5 pits/mm as in *A. kirtlandius* from Kirtland and Fruitland Fms.

The new Menefee turtle discoveries contribute to a growing understanding of Campanian fauna from the San Juan Basin. The turtle assemblage consists of large, freshwater channel-inhabiting baenids; a semiterrestrial helochelyrid; highly aquatic, brackish-tolerant trionychids; and a freshwater, potentially brackish-tolerant adocid. The combination of taxa suggests paleoenvironmental conditions consistent with a

coastal freshwater or partially brackish fluvial system. Updated stratigraphic ranges allow more accurate characterization of turtle evolution within the San Juan Basin and comparison with other Late Cretaceous North American sites.

Funding Sources The David B. Jones Foundation

Technical Session 10: Soft Tissues & Taphonomy (Friday, November 4, 2022, 8:00 AM)

A NOVEL HOLISTIC APPROACH TO TAPHONOMIC ANALYSES OF TROPICAL CAVE FOSSILS

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Critically, conventional direct dating of fossils can form a timeline of hominin and associated faunal arrival, migration, settlement, and extinction patterns. However, fossiliferous deposits in caves are not static; they are disturbed by complex infilling, deposition, and reworking over long periods, particularly in tropical climates, and this can strongly affect stratigraphic integrity. These complex processes have made it difficult to ascertain the provenance of vertebrate remains in tropical cave environments and the taphonomic factors that influence them. Natural mixing processes in tropical caves could lead to several different ecosystems separated by tens of thousands of years appearing to have co-existed, which may have serious implications for our understanding of environmental change and biodiversity responses in the tropics, and thus reshape the narrative of our ancestor's colonisation and migration patterns. It is crucial, therefore, that a robust understanding of cave taphonomy be undertaken to enable conventional dating methods to be confidently applied and fulfil their considerable potential.

A novel holistic approach is used to resolve mechanisms of site formation, depositional history, and faunal accumulation in tropical caves, vitally conserving the original integrity of excavated fossiliferous deposits to analyse taphonomic histories that would otherwise have been destroyed using conventional analyses and excavation methods. This research represents a unique taphonomic effort in the tropics to integrate multi-scale and multi-dimensional techniques to contextualise palaeontological material, namely neutron tomographic analysis and micromorphology. A minimally destructive contextual multi-methodological approach interprets the various formation processes rather than reconstructing sedimentation rates through direct dating methods, and thus underlines the biases inherent in the conventional techniques. This study generates a more complex and complete model of taphonomy and site formation history in tropical caves which has the potential to inform on the accuracy of previously calculated ages and the true contemporaneity of faunal remains contained within.

Technical Session 11: Synapsida (Friday, November 4, 2022, 8:00 AM)

CUT AND TEAR: ORAL PROCESSING IN THE HETERODONT NON-MAMMALIAN SYNAPSID *DIMETRODON* THROUGH FINITE ELEMENT ANALYSIS

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The emblematic Early Permian (295 – 270MA) non-mammalian synapsid *Dimetrodon* is classified as an ecological apex predator exhibiting the first instance of ziphodont dentition in a terrestrial animal. *Dimetrodon* has a heterodont dentition with broad incisiform teeth on the premaxilla, a large caniniform tooth, and subsequent smaller 'teardrop-shaped' cheek teeth along the maxillae. The biomechanical effectiveness of this heterodont dentition in early synapsids is unknown. To examine jaw performance[AUTH1], we scanned two skulls of *Dimetrodon incisivus* using computed tomography (CT) to digitize a cranial tetrahedral mesh. Muscle architecture was constructed based on areas of attachment and spatial constraints at a closed gape. Material properties were assigned based on extant anatomical tissue performance for multi-body dynamics analysis (MDA) where each muscle was replicated as a spring acting on the centroid of mandibular insertion. Point load cases were placed on the crowns of the teeth with force values obtained from MDA. Material properties were assigned based on extant anatomical tissue performance. While maintaining a dorso-ventral force of 4000 Newtons, fractional point forces were added at perpendicular vectors to simulate prey struggle. Biomechanical performance was evaluated from stress and strain patterns. Following these simulations, forces were scaled until repeated structural failure at each tooth was achieved. The caniniform tooth was best able to distribute unidirectional force assessed by low-stress pattern magnitudes. Incisiform teeth sustained greater lateral forces before crown failure. Cheek teeth saw the highest magnitude of stress distributed in the skull. These results show topological optimization for caniniform teeth, suggesting *Dimetrodon* was capable of orally processing large-bodied prey.

Funding Sources Funded by an NSERC discovery grant to Dr. Kirstin Brink as well as a Research Manitoba studentship and grant from the Paleontological Society to Adam Snyder.

Technical Session 5: Amphibians & Early Reptiles (Thursday, November 3, 2022, 8:00 AM)

TESTING FOR COMPLEX BODY SIZE EVOLUTION IN TEMNOSPONDYLS AND MODERN AMPHIBIANS WITH PHYLOGENETIC COMPARATIVE METHODS

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Current hypotheses on the origin of modern amphibians suggest the involvement of the evolution of extreme size reduction in their Paleozoic and Mesozoic tetrapod relatives, whether from temnospondyls or lepospondyls. The evolution of diminutive body size—miniaturization—is characterized by a mélange of complex structural changes due to physical and developmental constraints, and not merely a change in body size. Previous studies on the role of miniaturization in modern amphibian origins focused on the analysis of morphological changes in early tetrapods that accompany the hypothesized extreme body size reduction. However, the mode, direction, and tempo of evolution has yet to be explored under a statistically testable hypothesis in a phylogenetic comparative framework.

While temnospondyl diversity covers a wide range of body sizes, this range could have been obtained from an ancestrally “average” body size that diversified under random variation. It is important to identify if smaller body sizes evolved more than expected in diminutive lineages, compared to the idealized null hypothesis of the Brownian motion mode of evolution, in which random variation in size change led to the evolution of a broad diversity of body sizes ranging from large to small. Additionally, modeling the ancestral body size would provide statistical support that smaller body sizes are evolving from ancestors with relatively large body sizes. That is to say, if miniaturization occurred, extremely small body size evolved more than expected under random variation from a larger ancestral body size condition and is accompanied by morphological changes as described in previous studies.

Here, we reconstruct body size evolution of Paleozoic and Mesozoic temnospondyls and modern amphibians using body mass data and model the evolutionary tempo and mode under Brownian motion, evolutionary stasis, driven trends, and trended random walks. Understanding these patterns in early tetrapods is key to understanding patterns in the evolutionary origin of modern amphibians.

Funding Sources Special thanks to the Wilbur V. Harlan Trust for funding the graduate research fellowship supporting this study.

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

THE EVOLUTION OF PROCUMBENCY IN GEOMORPHA: THE INFLUENCE OF LOCOMOTORY SPECIALIZATION

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Procumbency (anteriorly projecting incisors in relation to the rostrum or dentary) has been studied extensively in many fossorial rodents, including within *Thomomys*, a genus of pocket gopher in the clade *Geomorpha*. However, few analyses have considered the evolution of procumbency over geological time scales. *Geomorpha* rodents offer this opportunity thanks to recent developments of a phylogenetic framework for the clade. Using data on both upper and lower incisor procumbency as well as phylogenetic information, we explore ecological specialization, canalization, and the macroevolution of procumbency in a taxonomically and ecologically diverse rodent clade. Specifically, we used linear measurements from 115 specimens of fossil and extant taxa, conducting ANOVAs and linear regressions at the family level and within families. We also performed an ancestral character state reconstruction for both upper and lower procumbency. We find that across all observed families, upper incisor procumbency is lower and less variable than lower incisor procumbency. The *Geomyidae* display a higher level of upper incisor procumbency than *Heteromyidae* and *Florentiamyidae*. They also have the least variable procumbency. The lower incisor procumbency of *Geomyidae* is similar to that observed in *Heteromyidae*. *Geomyids* are the only clade to exhibit a significant correlation between upper and lower procumbency. Character state reconstructions reveal that increased upper procumbency evolved multiple times within the extant subfamily of *Geomyidae*, in four different *geomyine* genera. Procumbency decreased independently multiple times within *Heteromyidae* as well in *Florentiamyidae* from a common ancestor with higher procumbency. We conclude that higher upper procumbency evolved in relation to burrowing, including in taxa that do not use their incisors as a primary mode of digging. Restriction to higher levels of upper procumbency, coupled with strong correlations between upper and lower incisor procumbency, suggest the existence of morphological canalization associated with fossoriality within *Geomyidae*.

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

A NEW DREPANOSAUR UNGUAL MORPHOTYPE FROM THE SONSELA MEMBER OF PETRIFIED FOREST NATIONAL PARK

Sodano, Megan P.¹, Kligman, Ben¹, Stocker, Michelle¹, Marsh, Adam², Parker, William G.², Nesbitt, Sterling J.¹

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Understanding the anatomical characteristics, and thus morphotypes, of reptile unguals can help us to better

understand diversity and lifestyles of the taxa who possess them. One of the most unique clades found in the Late Triassic is the Drepanosauromorpha, a clade of relatively small (>45 cm total length) neodiapsid reptiles that may represent a wide range of ecological lifestyles, from arboreal to fossorial. These taxa are recognized by the anatomical features of their second unguals, which are sometimes enlarged and distinct from their other manual unguals. Many of these taxa are known from the Upper Triassic Chinle Formation, spanning roughly 15 million years, including *Skybalonyx skapter*, *Ancistronychus paradoxus*, *Dolabrosaurus aquatilis*, *Avicranium renestoi*, and a *Drepanosaurus*-like taxon. A new and undescribed taxon of drepanosaur is described here from the Bowman Site (Revueltian) at Petrified Forest National Park, located within the Sonsela Member of the Chinle Formation. These unguals are relatively small and wide, 1.0 to 1.5 cm in length, 0.3 to 0.5 cm in length, and 0.8 to 1.0 cm in depth from the apex of the dorsal ridge to the ventral tubercle. They have distinctive deep grooves on the lateral and medial surfaces, sub-millimeter anastomosing grooves on the ungual's surface close to the distal tip, and a large rounded tubercle on the ventral surface halfway through its length. There is a rounded dorsal surface, unlike *Drepanosaurus*-like unguals which are mediolaterally compressed and possess a strong dorsal ridge, those of *Skybalonyx* which have a triangle-like shape in cross-section, and those of *Ancistronychus* which have a relatively flat dorsal surface and are square in cross-section. This new morphotype occurs in the same layer as the *Drepanosaurus*-like morphotype and appears to be a second taxon from this locality. This new taxon is thus far restricted to the early part of the Revueltian holochronozone, and may be useful as a biostratigraphic marker in the Chinle depositional basin. Additionally, having two distinct second manual ungual morphotypes from this locality indicates multiple Drepanosauromorph taxa after the Adamanian-Revueltian boundary.

Funding Sources David B. Jones Foundation, NSF EAR 1943286

Technical Session 15: Theropods (Saturday, November 5, 2022, 8:00 AM)

THE SIGNIFICANCE OF 'MULTI-LAGS' IN CORTICAL BONE INFERRED FROM A LARGE HISTOLOGICAL SAMPLE OF THE THEROPOD DINOSAUR *ALLOSaurus*

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In paleohistology, a line of arrested growth (LAG) is recognized as a thin ring in cortical bone that represents a temporary cessation of tissue apposition. LAGs are hormonally entrained features that record the circumference of an element during what generally corresponds to a season of

resource scarcity. LAGs are not always single rings but can be made up of multiple rings that sometimes diverge along their path around the bone, bounding thin deposits of interstitial tissue that have reduced or absent vascularity and cellularity. These anomalous LAGs are commonly referred to as 'double LAGs', 'triple LAGs', or 'supernumerary LAGs', all of which we refer to as 'multi-LAGs'. Multi-LAGs have been reported in a wide variety of vertebrates, including extinct and extant mammals, squamates, amphibians, and archosaurs, including birds. The handful of studies that have focused on multi-LAGs have tentatively linked their presence to the attainment of sexual maturity, hibernation, or migration, but the physiological or environmental cues underlying their formation remain unknown. To better understand the distribution and causes of multi-LAGs, we investigated their presence in the Jurassic theropod dinosaur *Allosaurus*. The sample consists of 12 femora and three tibiae, all from different individuals. We inferred growth models from age-body mass estimates for each specimen using nonlinear regression. Specimens in the dataset had a 20-fold variation in estimated body mass at the time of death, 6.5-fold variation in estimated asymptotic body mass, threefold variation in estimated age at death, and were recovered across 5° of paleolatitude. In total, nearly 150 LAGs were traced, with 23 (16%) of them being multi-LAGs. Of the 23 multi-LAGs, 16 are double LAGs (70%), six are triple LAGs (26%), and one is a quadruple LAG (4%). Paleolatitude, perhaps a proxy for environmental differences over the ~550 km north-south transect represented in the dataset, had no relationship with the presence or number multi-LAGs nor the number of sub-rings within multi-LAGs. Asymptotic body mass, body mass at the time of death, and age at death (i.e., longevity) were likewise uncorrelated with the presence or number of multi-LAGs. Stochastic environmental factors may underlie the development of multi-LAGs in *Allosaurus*; alternately, hidden taxonomic or sex-specific differences may be revealed to explain their development upon sampling of a larger dataset.

Funding Sources Jurassic Foundation Research Grant, Paleontological Society Steven M. Stanley Student Research Award

Colbert Prize Session

CRANIAL ONTOGENETIC VARIATION IN *PSITTACOSAURUS* WITH A CLADISTIC APPROACH AND ITS CONGRUENCE WITH CHRONOLOGICAL AGE

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To incorporate ontogenetically variable character data and character scorings from immature individuals into a phylogenetic analysis, character state changes across ages

should first be recorded at the species level for multiple taxa. *Psittacosaurus* is one of the best-sampled dinosaur genera in the fossil record and the most speciose genus of dinosaur, with ten currently accepted species. Histological data for *Psittacosaurus* specimens from China, Mongolia, and Russia have been reported, showing different life history strategies for each analyzed species. However, no study has comprehensively examined changes in character states or characters specific to an ontogenetic stage. Here we focused on cranial characters, binary to multistate transformation series that change through ontogeny, to build a character matrix of ontogenetically variable characters. Data from *Psittacosaurus lujiatunensis* provide the framework of the analysis, with the chronological age of specimens ranging from less than a year old to fully mature individuals of more than ten years old. As previously reported, commonly used body measurements are correlated with age. The efficacy of size-independent character changes for assessing maturity and assigning a specimen to an ontogenetic stage was tested by treating the ontogenetic hierarchy as a form of phylogenetic hierarchy. A matrix of ontogenetically variable characters for *P. lujiatunensis* was analyzed with TNT, recovering one most parsimonious tree (i.e., ontogram). The ontogram constructed from character state changes is incongruent with the ontogram based on age and size rankings. Although some histological age groups cluster in the character ontogram, others are separated by varying patristic distances. By comparing the growth patterns of different species in a phylogenetic framework, underlying evolutionary mechanisms, such as heterochrony, may be detected, and taxonomic debates could be settled with implications in species diversity. However, our study shows that in *Psittacosaurus* many traits used for taxonomy and systematics do not appear in an age-correlated sequence, and interpreting them accurately requires access to a histologically based growth series.

Funding Sources National Science Foundation, Frontier Research in Earth Science award (#1925884)

Education & Outreach Poster Session

WHERE THE WILD THINGS WERE: AN ONLINE INTERACTIVE ATLAS OF CHARISMATIC ANIMAL LOSSES FROM THE PLEISTOCENE THROUGH TODAY

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Although many people are concerned about modern anthropogenic biodiversity losses, few know of the parallels between current trends and the late-Quaternary extinction event (LQE). The LQE peaked around the end of the Pleistocene and resulted in the loss of about half the world's large mammal species. This occurred through human

population pressures, global warming, and other environmental changes that have transcended prehistoric, recent, and modern times. Highlighting these continuous but accelerating trends could promote awareness of the scale of the impending sixth mass extinction and its historic precedents. This in turn could promote engagement with Quaternary paleontology and conservation to reverse species losses. For this goal, we created a pilot version of *Where the Wild Things Were* (WTWTW): an online, interactive, and accessible atlas of charismatic animal losses from the Pleistocene to today. Through this atlas, we seek to instill a sense of place connecting users with animal losses through time to inspire effective conservation action. We began developing WTWTW with the quantitatively-most charismatic animals in mind. Elephants and large cats ranked highest on this list, so we focused our pilot maps on those animals within the United States (with mammoths being elephants) to cater to our expected audience. To make our maps, we used ArcGIS StoryMaps for its quick point-and-click development platform, with desktop and mobile user capabilities. We gathered natural history, occurrence, locality, range, and conservation information from paleoinformatics and bioinformatics databases [e.g., the Neotoma Paleocology Database, the International Union for Conservation of Nature (IUCN) Red List], as well as textbooks and peer-reviewed scientific articles. We investigated to the level of primary (often archival) materials as often as possible for scientific and geographic accuracy. We have shared this pilot atlas (<https://tinyurl.com/2s36rnpp>) through the University of California Museum of Paleontology's website platform (the collection of which receives over 2 million visitors monthly) and social media channels. We are interested in gathering additional feedback regarding taxa and functionalities to add, geographic regions to explore, and narratives to build. We also seek to develop WTWTW lesson plans for undergraduate courses and gain feedback following their use.

Funding Sources *Where the Wild Things Were* is supported by a Paleontological Society Education & Outreach Grant.

Technical Session 13: Early Archosaurs & Pterosaurs (Friday, November 4, 2022, 1:45 PM)

NEW INSIGHTS INTO THE ARCHOSAUR FAUNA (NEOTHEROPODA; PSEUDOSUCHIA; CROCODYLOMORPHA) FROM THE LATE TRIASSIC FISSURE FILLS LOCALITY OF PANT-Y-FFYNNON WALES (UK)

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The Late Triassic to Early Jurassic fissure fill localities of the Bristol Channel area preserve a diverse fauna of mostly small-bodied vertebrates, which has provided important insights into the early evolution of major tetrapod groups such as mammaliaforms, rhynchocephalians, crocodylomorphs, and dinosaurs. The Late Triassic site at Pant-y-ffynnon yields a particularly rich, but poorly understood assemblage of archosaurs, including the recently named theropod dinosaur *Pendraig milnerae*, the cursorial crocodylomorph *Terrestrisuchus gracilis*, the small sauropodomorph *Pantydraco caducus*, and the enigmatic pseudosuchian *Aenigmaspina pantyffonnensis*. Ongoing research has revealed several new insights into this fauna. *Pendraig* is identified as a small-sized non-coelophysid coelophysoid dinosaur. A revision of *Aenigmaspina*, characterised by unique, bifurcating osteoderms and conspicuously T-shaped neural spines on the cervical and anterior dorsal vertebrae, recovers this genus as the sister taxon of Erpetosuchidae + Aetosauriformes in a new phylogenetic analysis. Finally, CT-scanning has elucidated the braincase anatomy of *Terrestrisuchus gracilis*, highlighting several features likely plesiomorphic to Crocodylomorpha, such as a quadrate that is not fused to the braincase. Together, these studies underline the importance of the Late Triassic-Early Jurassic fissure fills fauna of the UK for our understanding of early archosaur evolution and diversity.

Funding Sources This research has been funded by a Swiss National Science Foundation Early Postdoc Mobility Fellowship to Stephan Spiekman (P2ZHP2_195162).

Technical Session 17: Fish (Saturday, November 5, 2022, 8:00 AM)

A NEW EARLY PERMIAN RAY-FINNED FISH (ACTINOPTERYGII) EXPOSES ROGUE TAXA THAT OBSCURE THE DIVERGENCE OF THE ACTINOPTERYGIAN CROWN GROUP

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The emergence of living ray-finned fish lineages (the actinopterygian crown) from more ancient groups is obscured by the blending of Paleozoic species into a paraphyletic wastebasket called the “paleoniscoids”. Molecular clock studies predict that the actinopterygian crown group arose in the Paleozoic. However, parsing out the timing and context of the divergence of extant lineages from the “paleoniscoids” is obstructed by a dearth of well-preserved actinopterygian fossils from late Paleozoic (Late Pennsylvanian through Permian) deposits. We describe a new ray-finned fish from the early Permian Minnekahta Limestone of South Dakota to help bridge that Late Paleozoic gap. The new taxon is known from

two small (~6 cm in standard length), laterally compressed specimens with “paleoniscoid” features, including an immobile maxilla with a broad postorbital plate, rhombic, ganoine covered scales, and a heterocercal caudal fin. The new taxon is distinct from other “paleoniscoids” in possessing two supraorbitals, a subopercle that is larger than the opercle, an enlarged last branchiostegal ray, and three suborbitals. Our maximum parsimony and Bayesian phylogenetic analyses place the new taxon in an unresolved group of “paleoniscoids” with an uncertain relationship to the actinopterygian crown. We analyzed the results of our phylogenetic search to see if rogue taxa with conflicting positions introduced uncertainty. Our analyses encountered one to five rogue taxa (parsimony and Bayesian results, respectively), including the new taxon, three other early Carboniferous and Triassic “paleoniscoids”, and the early Jurassic *Chondrosteus acipenseroides*. Phylogenetic uncertainty for the new species and other “paleoniscoids” centers around membership within or exclusion from the actinopterygian crown group. Therefore, “paleoniscoids” likely include a mix of stem and crown taxa, creating phylogenetic conflict surrounding the diversification of crown Actinopterygii. Our work may illuminate unrecognized members of the actinopterygian crown group predicted by molecular clock studies. Careful reexamination of these rogue taxa is needed to determine the cause of their behavior, remedy the ill effect of rogues on future phylogenetic analyses, and better delineate the early evolutionary history of the actinopterygian crown.

Funding Sources Michigan State University Distinguished Fellowship/Department of Earth and Environmental Sciences Alumni Fellowship and Paleontological Society Rodney M. Feldmann Award.

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

END OF THE LINE: QUANTIFYING THE DEMISE OF HYBODONTIFORM SHARK-LIKE CHONDRICHTHYANS

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Elasmobranch (modern sharks and rays) and extinct hybodontiform fishes were the dominant chondrichthyan lineages during the Mesozoic, with elasmobranchs having a fossil record extending back into the Permian, but probably even reaching farther back since hybodontiforms representing their sister group are supposed to have originated in the Devonian. However, it was only in the late Early Jurassic, about 180 Ma ago, when elasmobranchs began to diversify rapidly to become the prevailing chondrichthyan group. The sudden radiation of elasmobranchs is widely considered to have had been negatively affected hybodontiforms due to increasing competition, which is assumed to have resulted in a diversity decline and subsequent displacement of

hyodontiforms towards continental waters before they finally went extinct at the K/Pg boundary. However, no detailed analyses have been conducted so far to test this hypothesis. In an attempt to better understand macroevolutionary patterns of Mesozoic chondrichthyans, we analyzed the generic diversity of Jurassic to Cretaceous elasmobranchs and hyodontiforms. Accordingly, we found evidence that hyodontiform diversity increased in the Jurassic, in particular during the Bathonian–Kimmeridgian interval. By the Early Cretaceous, hyodontiforms appear to have reached a diversity plateau spanning from the Berriassian to the Barremian, before dropping during the Aptian–Cenomanian interval. Diversity dynamics of Jurassic elasmobranchs resemble those of hyodontiforms in displaying an increasing trend, which suggests that both groups may have used different adaptive traits to partition available niche spaces efficiently. Cretaceous diversity trends, however, diverge substantially, resulting in the final demise of hyodontiforms, which might indicate increased competition with elasmobranchs eventually outcompeting hyodontiforms. This divergent pattern, however, rather correlates with hyodontiforms adapting to freshwaters after the Jurassic and following thus different evolutionary pathways than elasmobranchs in marine environments without direct competition.

Funding Sources Austrian Science Fund (FWF) [P 33820]

Technical Session 18: Birds (Saturday, November 5, 2022, 1:45 PM)

EXTENSIVE HOMOPLASY IN THE APPENDICULAR SKELETON OF PASSERINE BIRDS

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The hyperdiverse crown bird subclade Passeriformes (passerine birds) comprises more than half of extant avian diversity, yet disproportionately few studies have attempted to understand the evolution of skeletal morphology across the group. The sheer taxonomic diversity of passerines coupled with the notion that passerine skeletons are morphologically ‘uniform’ has dissuaded attempts to study passerine comparative anatomy on a large scale. Using morphology alone to resolve passerine relationships beyond the subordinal level has been notoriously difficult, and it is only recently that phylogenetic relationships among family-level clades have been resolved by phylogenomic data. Here, we investigate the extent of morphological convergence in the passerine skeleton by quantifying homoplasy in the passerine carpometacarpus and tarsometatarsus, which are morphologically labile and functionally important bones within the wing and hindlimb, respectively. Incorporating a robust phylogenomic backbone topology for passerine relationships with anatomical character-taxon matrices across a comprehensive sample of extant passerines, we calculated consistency (CI) and retention

(RI) indices in addition to homoplasy excess ratios (HER). HER measures the extent of homoplasy in a dataset compared to randomly simulated character matrices of the same dimensions and character state proportions. We show that the carpometacarpus, tarsometatarsus and a combined matrix of both exhibit low CI and RI values and very low HER values, illustrating high levels of homoplasy in these skeletal elements. This study has important implications for interpreting the passerine fossil record, which contains a relative abundance of these appendicular elements due to their comparative taphonomic recalcitrance. Our results illustrate the importance of incorporating molecular scaffolds when attempting to diagnose isolated passerine carpometacarpi and tarsometatarsi from the fossil record.

Funding Sources This work was supported by UKRI Future Leaders Fellowship MR/S032177/1 to DJF; NERC NE/S007164/1 and an American Ornithological Society Research Award to EMS.

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

POSTCRANIAL ANATOMY OF *FRUITACHAMPSA CALLISONI* FROM THE UPPER JURASSIC MORRISON FORMATION OF WESTERN COLORADO

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Fruitachampsia callisoni is a small crocodyliform (femur: length ~57 mm, midshaft diameter ~4 mm) from the Fruita Paleontological Area (FPA) of the Morrison Formation and records both a critical ecology and clade previously unknown during the Late Jurassic in the western US. The initial description of *Fruitachampsia* was based on several well-preserved skulls and incomplete postcrania. Slender limbs suggested terrestriality; however, limited postcranial material prohibited further interpretations. Based largely upon its skull morphology, phylogenetic analyses recover *Fruitachampsia* among early Crocodyliformes. An additional nearly complete postcranial skeleton (LACM 154921) was recovered from the FPA in the 1970s, but absence of associated skull material made it challenging to assign it to either a new or existing taxon. Earlier preliminary work suggested it might represent a new sphenosuchian based in part on its limb proportions and ankle morphology.

Recently we collected CT data for the *Fruitachampsia* paratype blocks and LACM 154921. To better characterize *Fruitachampsia* morphology and explore whether these specimens could be conspecific we undertook extensive

reanalysis of the paratype material and digital segmentation of the CT data. We conclude that LACM 154921 is attributable to *F. callisoni* based on numerous features, including aspects of the caudal vertebrae, scapula, humerus, and elongate gracile limbs with an ~ 1:1 femur to tibia proportions. Femur morphology of LACM 154921 is identical with known *Fruitachampsia* femora, and unlike the highly modified femora of *Macelognathus vagans*, another crocodylomorph known from the FPA. Additional discoveries among the *Fruitachampsia* paratype include a previously unidentified, slender bone articulating with the distal forelimb, consistent with the apomorphically elongate radiale and ulnare of LACM 154921. The segmented pelvis of LACM 154921 reveals a slender pubis excluded from the acetabulum. The referral of LACM 154921 to *Fruitachampsia* and the CT data from the paratype means that *Fruitachampsia* now possesses one of the best represented postcranial skeletons among early crocodyliforms. The long gracile limbs and pelvic morphology of *Fruitachampsia* compare well with putative close relatives like the Asian *Sichuanosuchus* and the Gondwanan *Neuquensuchus*. The carpal elements in *Fruitachampsia* are some of the longest known for crocodylomorphs suggesting extreme modification related to its presumed terrestrial ecology.

Funding Sources NSF DEB 175459

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

FOSSIL HERPETOFAUNA OF PEDERNALES PROVINCE, DOMINICAN REPUBLIC: NOVEL RECORD OF HUMAN-INDUCED EXTINCTION AND EXTIRPATION

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Hispaniola is the second-largest island of the Caribbean Islands and provides key insight into the biodiversity of the region. In an effort to expand the record of taxa that are often overlooked, we investigated the herpetofauna of a new series of Holocene dry cave fossil sites located in the Pedernales province of the Dominican Republic. Herpetofauna are an important and diverse group of animals within the Caribbean ecosystems, representing the most diverse clade of vertebrates in the Caribbean. They are an incredibly interesting group of animals that have thrived on the earth for hundreds of millions of years.

Excavations of the caves range from 0-10 cm to >100 cm deep, and likely represent deposits from owls dwelling in the caves. Fossils were excavated and documented layer-by-layer. Several genera of squamates (*Ameiva*, *Anolis*, *Celestus*, *Cyclura*, *Leiocephalus*, and Geckos) were identified by dentition and recorded in their abundance at each depth. *Anolis*, *Celestus*, and Geckos each represented a large portion

of the material at most depths. *Cyclura* and *Ameiva* were consistently the least abundant. *Leiocephalus* were absent from surface depths. Fossils of *Crocodylus rhombifer* (the first occurrence not on the east coast of the island), *Haitiophis anomalus*, *Chilabothrus*, *Uromacer*, *Hypsirhynchus*, *Osteopilus*, *Eleutherodactylus*, and *Peltophryne* from the region were also identified.

From this collection, we were able to identify two new species of *Celestus*, one new species of *Cyclura*, and revise the taxonomy of *Leiocephalus*. The extirpation or extinction of these species is likely due to the arrival of humans to Hispaniola, a trend previously reported in other mammalian taxa. The first people arrived ~6,000-7,000 years B.P., with a second more significant migration of people from Europe beginning 530 years B.P. These arrivals of humans, along with their domesticated animals and associated pests (mice, rats, etc), had a dramatic influence on the ecosystems in Hispaniola and are likely the cause of many extinctions and extirpations. Further radiocarbon and geochemical sampling of these herpetofaunal fossils will help assess when and why these species went extinct.

Technical Session 5: Amphibians & Early Reptiles (Thursday, November 3, 2022, 8:00 AM)

THE AXIAL SKELETON OF *TIKTAALIK ROSEAE*

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The vertebrate water to land transition is marked by a suite of changes to the skeleton. Most research into this transition has focused on the evolution of the cranial skeleton and paired appendages. However, understanding transformation of the axial column is critical to understanding the biomechanics and ecology of early tetrapods. Here, to understand how the axial column of early tetrapods evolved, we studied *Tiktaalik roseae*, an elpistostegalian closely related to the earliest limbed vertebrates. The holotype specimen, NUFV 108, was CT scanned at The University of Chicago, revealing a vertebral column, and new details of the ribs and pelvic fin. Intercentra (n=34) show minor, graded differences in morphology. More posteriorly, the intercentra are longer in the rostral-caudal direction and shorter dorsoventrally. Neural arches (n=29) show a number of distinct types. Anteriorly, they have a simple saddle shape. More posteriorly, distinct neural arch types are characterized by dorsal foramina and dramatically increased robustness. Ribs (n=56) are preserved, including a complete series of 32 from the left side. Anteriorly, ribs are straight, and they begin to curve ventrally at rib 5. At approximately rib 20, the ribs shorten and are more triangular in shape. Ribs 31 and 32 are markedly distinct in

their morphology, curving ventrally. An isolated post-sacral rib is also preserved. An abrupt shift in neural arch morphology coincides with the position of rib 32, indicating a trunk-to-tail transition and position of the pelvic girdle. Thus, we diagnose the presence of sacral rib, which would have been associated with the pelvic girdle, linked by soft tissue. CT scans allow identification of new endoskeletal elements of the pelvic fin and description of the full pelvic fin web. The morphology of *T. roseae* is compared to other tetrapodomorphs, and we conclude that its ribs show a pattern of regionalization similar to *Acanthostega*. Thus, patterns of axial column regionalization seen in early tetrapods originated in an aquatic context prior to the fin-to-limb transition.

Funding Sources National Science Foundation (EAR 0207721 to EBD, EAR 0544093 to EBD, EAR 0208377 to NHS, and EAR 0544565 to NHS), The Brinson Foundation

Symposium: A Late Miocene Shangri-la (Wednesday, November 2, 2022, 1:45 PM)

THE DIVERSE WATERBIRDS OF THE LATE MIOCENE SITE OF SHUITANGBA (YUNNAN PROVINCE, CHINA) AND THEIR HABITATS

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Excavations of the Shuitangba site have produced the most diverse late Miocene avifauna known from southeastern Asia. While most of the abundant bird fossils have been recovered as individual or broken skeletal elements, the avian diversity represents a wide range of body sizes from large anserines to very small passeriforms, and a diversity of ecologies of terrestrial, arboreal, aerial, and aquatic habitats. In particular, this site hosts the oldest known diverse assemblage (or guild) of piscivorous foot-propelled diving birds which includes members of the extant clades of grebes, cormorants, darters, and diving ducks, along with pelicans. The extinct medium-sized grebe taxon with its hypotarsal canal for the tendon of m. flexor perforans digiti II and tarsometatarsus morphology appears to support its identification as the first member of *Rollandia* + *Podylimbus* clade in the Old World. *Aythya shihuibas* is the most common duck taxon, and it exhibits a pneumatic pneumotricipital fossa, a continuous ridge around the dorsal epicondylar region, and a pneumatic ventral tubercle that points to a phylogenetic position on the *Aythya* stem, and differentiates it from the closely related *Netta*. A small-sized extinct species of darter is known from much of the skeleton, and its tarsometatarsus helps to support it as a member of the Old World clade of crown anhingids. A small-sized extinct cormorant, possibly referable to *Microcarbo* (based on the paroccipital process length and metatarsal trochlear extension), is known from the cranium, shoulder girdle, hindlimb, and other elements. This piscivorous guild

would have exploited fish and invertebrates in the rivers, lakes, and ponds in the vicinity of Shuitangba.

The avifaunal assemblage from Shuitangba contrasts strongly with that of the similar aged Linxia Basin fauna to the north with its arid adapted and largely terrestrial bird taxa. The waterbird assemblage with smaller sized divers like the grebe and diving duck along with the larger (though small-sized for their clades) darter, cormorant, and pelican suggest a diversity of water depths available in the fossil deposit area, ranging from less than one meter to as much as several meters deep. The avian assemblage also points to the past presence of open areas of water along with likely emergent vegetation and elevated/raised areas out of the water for the cormorants and darters to dry their feathers.

Funding Sources National Natural Science Foundation of China (grant # NSFC42172029)

Virtual Posters

ANALYSIS OF A PATHOLOGICAL COLUMBIAN MAMMOTH (*MAMMUTHUS COLUMBI*) THIRD MOLAR AND COMPARISONS TO OTHER PROBOSCIDEANS FROM CLARK COUNTY, KANSAS WITH IMPLICATIONS FOR PALEOECOLOGY AND DIET

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Mammuthus columbi was by far the most common species of a mammoth in the continental United States during the Pleistocene epoch. These large mammals fed on grasses in the steppe of Ice Age North America, until their extinction ~11,000 years ago alongside other Pleistocene megafauna. A handful of specimens found in the late 1920s in Clark County, Kansas—including a highly pathologic molar of *M. columbi*—have remained relatively ignored in the University of Kansas (KUPV) Natural History Museum collection. Pathologies in mammoth teeth and bones have previously been linked to improper nutrition and have yet to be studied thoroughly in *M. columbi* specimens. Analyses of dental microwear and δC^{13} content of enamel in proboscidean teeth have been used to reconstruct diet and paleoenvironment in previous research and could potentially provide insights into the impact of climate change on the megafauna of Pleistocene North America. In this study, we compared the pathological *M. columbi* specimen with three other third molar specimens from the same locality: two *Mammuthus* sp. and one *Mammuth americanum*. We provide a comprehensive description of the pathological and non-pathological specimens. We also conducted a microwear analysis comparing pits and scratches

on select areas from each tooth and performed an isotopic analysis of the enamel δC^{13} content of each tooth. Preliminary results are inconclusive in reconstructing the dietary habits of the pathological mammoth and the paleoenvironment of southern Kansas during the Pleistocene. Preparation techniques performed during the 1920s have obscured some surficial features and additional preparation of these specimens is ongoing in an attempt to reveal more informative microwear. Additional research is necessary to demonstrate that the pathological *M. columbi* specimen was a result of improper nutrition, including a comparison to similar pathologies described in *M. primigenius* and living elephantids.

Funding Sources This work was supported by the University of Kansas (KU) Center for Undergraduate Research and the David B. Jones Foundation.

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

PINEAL FORAMEN VARIATION AS A WINDOW INTO SENSORY EVOLUTION, CONVERGENCE OF MAMMAL-LIKE CRANIAL TRAITS, AND MAJOR LINEAGE DIVERGENCES IN PRE-MAMMALIAFORM SYNAPSIDA

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Many pre-mammaliaform synapsids are inferred to have had a parietal eye based on the presence of a pineal foramen, although this structure disappeared independently in multiple therapsid and cynodont lineages. The morphology of the synapsid pineal foramen is highly variable, yet few studies address its morphological variation and disparity across the synapsid phylogeny as a whole, especially in relation to large-scale morphological changes that characterize the evolution of the mammalian cranium. For instance, convergent shifts to larger, more dorsally-oriented temporal fenestrae, evolution of the zygomatic arch, and narrowing of the intertemporal bar might have affected the size, shape, and/or location of the pineal foramen and the functionality of the parietal eye across multiple lineages. Addressing such questions could shed light on evolutionary pressures and mechanisms that contributed to independent losses of a seemingly valuable sensory structure and the evolution of increasingly mammal-like cranial traits. Here, we examine covariance between linear measurements of the pineal foramen and other dorsal skull features across Synapsida, and investigate whether major lineage divergences correlate with saltatory or clinal changes in pineal foramen and dorsal skull morphology. We find evidence of significant differences in pelycosaur and therapsid morphologies but more clinal variation among various therapsid lineages. We also find relatively strong phylogenetic signal in the placement

of the pineal foramen along the sagittal axis of the skull (Pagel's lambda ranges from 0.753 to 0.790), which is indicative of this trait approaching a Brownian motion model of evolution. Intertemporal bar narrowing strongly correlates with lateral compression of the pineal foramen, which may signify decreased functionality or even vestigiality of the parietal eye. Such instances of pineal foramen reduction might indicate points on the synapsid phylogeny where the parietal eye became less important in sensory systems and circadian rhythm regulation and the functional benefits of larger jaw musculature were able to take precedence. Therefore, broad-scale morphological shifts toward mammal-like dorsal crania may have helped set the stage for convergent losses of the parietal eye, most notably in the ancestors of mammaliaforms.

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

MIDDLE MIOCENE CETACEAN FOSSILS FROM SHARKTOOTH HILL

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The Round Mountain Silt bonebed of Sharktooth Hill (STH), Kern County, California, provides a valuable record of middle Miocene cetacean abundance and diversity. Mysticetes in particular saw high levels of taxonomic richness, as well as the appearance of several extant clades. The bonebed of Sharktooth Hill was formed 15-16 million years ago by the long-term deposition of bones and teeth on the sea floor, accumulating over a time period of roughly 700,000 years with little to no net sedimentation. Identification and morphological comparison of fossils found at Sharktooth Hill contribute to both ecological and evolutionary understandings of middle Miocene Cetacea. Calculating relative abundance from the fossil record can inform an understanding of Miocene ecosystems, and the appearance of certain morphological characters in the fossil record can reveal evolutionary relationships. The focus of this research was to describe and identify fossils collected from the Round Mountain Silt bonebed. The studied specimens included an occipital bone and three disarticulated vertebrae. The skull specimen was compared to 32 taxa using 17 characters. The calculated percent similarity indicated that the skull specimen likely belonged to a basal balaenid, and that it was most similar to the balaenid *Peripolocetus vexillifer*. In regards to the disarticulated vertebrae, measurements suggest that the lumbar and caudal vertebrae belonged to a whale within the estimated size range of the skull specimen. The size and shape of the third vertebra suggest that it belonged to a smaller cetacean or an extinct sirenian.

A NEW LONG-NECKED POLYCOTYLID (PLESIOSAURIA: POLYCOTYLIDAE) FROM THE PIERRE SHALE OF WYOMING, U.S.A.

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Plesiosauria was a successful group of secondarily marine reptiles that evolved and diversified during the Triassic and populated the world's oceans until their extinction at the end of the Cretaceous. Derived species typically fall into one of two morphotypes: plesiosauromorphs, with relatively small heads and longer necks, and pliosauromorphs, with relatively large heads and shorter necks. Polycotylidae is one of three clades that exhibit the pliosaur morphology. However, Polycotylidae is not closely related to the other two plesiosauromorph clades but is instead nested among plesiosauromorphs. Polycotylids possessed large skulls, due in great part to their elongated jaws. Basal species of the family from the Turonian had up to 30 cervical vertebrae, but previously described derived species from the Campanian to the Maastrichtian have reduced cervical series that include no more than 26 vertebrae.

A new specimen of polycotylid was recovered from the lower Maastrichtian upper Pierre Shale of Wyoming. The specimen was easily identifiable as a polycotylid by its narrow, elongated mandibles, which exhibit similar morphologies to well-known genera, such as *Dolichorhynchops* and *Polycotylus*. However, the new specimen possesses a complete cervical series comprising 32 vertebrae. Additional autapomorphies of the new specimen include the configuration of the mandibular bones and a large posterolateral projection on the pubis. Phylogenetic analysis revealed the new specimen to be a separate taxon, sister to a clade including the genera *Dolichorhynchops*, *Trinacromerum*, and *Georgiasaurus*. These findings indicate either a reversal to a longer neck condition in the new taxon or that longer necks persisted within Polycotylidae in species with currently incomplete cervical series, such as *Dolichorhynchops herschelensis*, *Eopolycotylus rankini*, or *Palmulasaurus quadratus*. In addition to having 32 vertebrae, the cervical series of the new taxon is notable in that the neural spines are proportionately tall and elongated anteroposteriorly. The size of the neural spines indicates that the epaxial muscles were likely robust and could have aided in rapid lateral flexion. The ability to perform fast motions of the neck, in combination with the narrow conical teeth observed in the specimen, suggests that this new taxon fed on small, agile prey.

SHUITANGBA: OVERVIEW, TAPHONOMY, AND PALEOENVIRONMENT

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Shuitangba in northeastern Yunnan Province, dated to 6.5-6.0 Ma using paleomagnetic correlation, is one of the few late Miocene fossil-bearing sites in southern China, providing a window to an important time period for our understanding of modern mammalian evolution. Its diverse vertebrate fauna includes mammals, birds, reptiles, and amphibians. The vertebrate fauna is dominated by birds, which are 62.9% of the assemblage; mammals comprise 24.6% of the fauna; reptiles (including turtles and crocodiles) and amphibians make up the remainder. Here, we examine the taphonomic factors evident at Shuitangba. In-depth taphonomic studies, which had not been previously carried out for Shuitangba, can impact our interpretations of paleoenvironmental reconstructions. Only mammals (NISP = 428) and birds (NISP = 495) were included in the analysis. Taphonomic factors that were examined include weathering, transportation, breakage, and animal damage (i.e., carnivore, rodent, and insect). All bones were examined under 10x magnification. Most bones showed little to no sign of weathering. There was minimal rodent or insect damage and carnivores did not appear to have been important in assemblage accumulation for mammals (0.9%), but were more so for birds (9%). Root etching was observed, indicating that many of the specimens had been shallowly buried. The results suggest that the bones at Shuitangba were not transported and that deposition was relatively rapid, likely along the shallow water margins. The results of the taphonomic analyses strengthen previous paleoenvironmental reconstructions, which suggest a densely vegetated habitat along a body of slow-moving water.

Funding Sources Fieldwork was supported by the U.S. NSF, the Yunnan Natural Science Foundation, Government of Zhaotong, and the IVPP through National Natural Science Foundation of China.

Preparators' Poster Session

A CALL FOR STANDARDIZATION OF DESTRUCTIVE ANALYSIS POLICIES

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As technology advances, there are a growing number of analytical techniques that require complete or partial consumptive sampling of fossil material. While these analyses can elucidate paleontological patterns and processes undetectable from traditional observations and measurements, consumptive sampling poses a risk to non-renewable fossil resources. This risk must be considered when creating destructive analysis policies, which are currently inconsistent or nonexistent in institutions throughout the United States (US). A survey was sent to 47 institutions with fossil collections in summer 2021 to determine what destructive analysis policies were in place in the US; 24 responses (51%) were received. The responses indicated destructive analysis policies were variable if existent. Three institutions indicated they do not have a written policy (two have informal guidelines requiring a proposal for destructive analyses), and one indicated a destructive analysis policy is not part of their collections management plan because they do not allow destructive analyses of their collections. 22 institutions indicated a form and/or formal proposal must be completed and submitted to museum personnel for consideration, and only eight institutions required archival documentation of fossil shape data (e.g., photography, 3D scanning, molding/casting). Based on these responses, three core guidelines are proposed for institutions with fossil collections. First, a consumptive sampling request form should be created by the institution and required for all destructive research requests. Forms should be structured so the merit and risk of each request can be objectively quantified to standardize approval decisions. Second, retention of fossil shape data should be required for all approved requests before consumptive sampling is done. Third, statistical evidence should be utilized to ensure 1) that collections are not over sampled and 2) that the number of specimens consumptively sampled is appropriate for project-specific objectives. These general guidelines are designed for institutions to incorporate into their collections management plan and modify as needed. Adaptation of these guidelines may improve the objectivity and reproducibility of request evaluations and facilitate responsible collections conservation practices so fossil data remains accessible for future research.

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

A PROBABLE PHAETHONTIFORM BIRD FROM THE TERRESTRIAL MIDDLE EOCENE (BARTONIAN) OF YUKON, CANADA

Sullivan, Corwin¹, Buryak, Serhiy¹, West, Christopher K.¹, Stidham, Reyes, Alberto¹, Thomas A.², O'Connor, Jingmai K.³, Zazula, Grant⁴, Vavrek, Matthew J.⁵

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In 1983, a block containing pennaceous feathers and wing bones of a fossil bird, alongside fossil leaves, was collected from a Palaeogene outcrop of intermontane basinal rocks near the subarctic Fifteenmile River in Yukon, Canada. The specimen, accessioned as Yukon Government (YG) palaeontological specimen YG 138, was briefly reported a few years later, but was not described or identified below Neornithes. At some point, the near-complete right humerus was fully prepared, while the articulated but incomplete left humerus, ulna, and radius were exposed partially.

Further preparation and comparisons to fossil and modern birds show that the Fifteenmile bird likely belongs to Phaethontiformes (tropicbirds and their fossil relatives), with a particular resemblance to *Prophaethon* from the lower Eocene London Clay of England. The Fifteenmile bird and *Prophaethon* share distinctive humeral traits including a dorsally prominent dorsal tubercle, a cranially directed deltopectoral crest, a bulbous dorsal supracondylar tubercle, a scapulotricipitalis sulcus, and a narrow and oblique ventral supracondylar tubercle. However, the Fifteenmile bird has some features not seen in *Prophaethon*, such as a more distally placed dorsal supracondylar tubercle. Other Palaeogene phaethontiforms, such as *Lithoptila*, are more distinct from the Fifteenmile bird, especially in the more dorsal orientation of the deltopectoral crest. The ulna of the Fifteenmile bird differs from that of *Lithoptila* in lacking quill knobs and in the subdued shape of the carpal tuber.

A devitrified tephra sample in close stratigraphic association with the outcrop that yielded the Fifteenmile bird was dated to 40.2 ± 0.9 Ma (Bartonian, middle Eocene), by U-Pb zircon geochronology. The specimen is thus the youngest Palaeogene phaethontiform from North America, and among the youngest globally. During the Bartonian, the Fifteenmile site was likely hundreds of kilometres inland, and analysis of the Fifteenmile palaeoflora indicates warm, dry summers and mild, wet winters. Modern tropicbirds are highly aerial seabirds that breed on oceanic islands and rarely swim, and previously described Palaeogene phaethontiforms are from marine rocks. However, the continental setting of the Fifteenmile bird adds to the evidence that Palaeogene phaethontiforms were less pelagic than extant tropicbirds and even suggests they were not exclusively marine, paralleling the presence of frigatebirds in the lower Eocene of Wyoming, USA.

Funding Sources National Sciences and Engineering Research Council of Canada Discovery Grant RGPIN-2017-06246, and start-up funding awarded to CS by the University of Alberta.

Technical Session 5: Amphibians & Early Reptiles (Thursday, November 3, 2022, 8:00 AM)

A NEW GENUS OF CAPTORHINID REPTILE (AMNIOTA: EUREPTILIA) FROM THE LOWER PERMIAN HENNESSEY FORMATION OF CENTRAL OKLAHOMA: DENTAL HOMOPLASY IN THE FAMILY CAPTORHINIDAE AND THE EARLIEST KNOWN EXAMPLE OF MINITURIZATION IN A BASAL AMNIOTE

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A new captorhinid reptile is described on the basis of materials originally assigned to *Captorhinos parvus* Olson, 1954, as well as more recently discovered and more complete materials from the same locality. All of the specimens are from the lower Permian Hennessey Formation in central Oklahoma. Most other taxa from similar sediments in the region are represented by minimal, often fragmentary remains. Materials ascribed to the new taxon include at least twenty partial to nearly complete skulls including all elements of the basal reptilian skull and adding significantly to the understanding of captorhinid cranial anatomy from a taxon exceeded only by *Captorhinus* in abundance. The new Oklahoman captorhinid is distinguished from all other members of the family by the unique combination of being the smallest known mature member of the family, the lack of the supratemporal, and possession of multiple maxillary and dentary tooth rows despite its extraordinarily small size. Characters from all previous assessments of the family over the past ten years were combined with new characters generated in this study and a phylogenetic analysis performed using TNT. Analysis places the new captorhinid within more basal members of the eureptilian family Captorhinidae. This placement suggests that multiple maxillary and dentary tooth rows must have developed independently at least three times within the family. With an adult skull size approximately one-third that of the other smallest captorhinids, the new taxon is a small, but well-ossified and mature, adult member of the family. This represents the first significant example of miniaturization in the family and demonstrates further that the family is a dramatic example of diversification within basal Amniota.

Symposium: A Late Miocene Shangri-la (Wednesday, November 2, 2022, 1:45 PM)

AN ISOTOPIC PERSPECTIVE ON HABITATS AND CLIMATIC CONDITIONS IN THE LATE MIOCENE SHUITANGBA

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Significant changes in global climate during the Neogene are thought to have had a profound influence on the evolution of mammals, including hominoids. In this study, we reconstructed the diets and environmental conditions of the late Miocene mammalian fauna in Shuitangba, an important refugium for hominoids in Yunnan (in southwest China), using stable isotopes in fossil teeth and freshwater mollusk shells. The tooth enamel $\delta^{13}\text{C}$ data indicate that the mammals living in the area during the Late Miocene had either pure C_3 or mixed C_3 - C_4 diets. The presence of C_4 plants in the diets of various herbivores suggests that local ecosystems contained C_4 grasses but were dominated by C_3 plants. The $\delta^{18}\text{O}_w$ values of paleo-meteoric water reconstructed from the $\delta^{18}\text{O}$ values of fossil teeth are on average lower than those inferred from modern samples and lower than the average $\delta^{18}\text{O}_w$ values of modern precipitation in the region. Serial $\delta^{18}\text{O}$ data show that fossil herbivores have a larger intra-tooth $\delta^{18}\text{O}$ variability than their modern counterparts in the area. Fossil freshwater shells also record larger seasonal $\delta^{18}\text{O}$ variations within individual shells and have lower $\delta^{18}\text{O}$ values than modern shells from a freshwater lake in the same region. Temperatures derived from clumped isotope analysis of shells suggest a mean annual temperature of ~15 to 16 in the Shuitangba area in the late Miocene, which is ~3 to 4 higher than that of today. Thus, the isotope data of mammalian teeth and freshwater mollusk shells from Shuitangba indicate that C_4 grasses existed in local ecosystems ~6.2 Ma, likely in patches of grasslands in a predominantly forested environment and that the climate in the area was warmer and wetter, possibly with a stronger seasonality in precipitation. Compilation of available isotopic records from the region suggests that C_4 biomass had spread earlier in the Siwalik region on the southwest side of the Tibetan Plateau than in Yunnan on the southeast side of the Plateau. The shift to a more open and drier habitat is also more pronounced and begins earlier in the Siwalik region than in Yunnan. The growth history of the Himalayan-Tibetan Plateau is possibly the main driver of the regional differences.

Virtual Posters

RECYCLING HEMOGLOBIN? – PRESERVATION OF *TARBOSAURUS BATAAR* BONE MICROSTRUCTURES IN IRON OXIDES

Surmik, Dawid¹, Gäb, Fabian², Sander, Martin P.², Kadziolka-Gawel, Mariola³, Dulski, Mateusz³, Slowiak-Morkovina, Justyna⁴, Szczygielski, Tomasz⁴, Pawlicki, Roman⁵

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Preservation of soft parts in fossilized bone has been shown from numerous locations and specimens before. Among those, the iron-mediated preservation is one of the possible pathways. However, the origin of the iron is still debated. Here, we present an in-depth, multiproxy investigation of *Tarbosaurus bataar* bone tissue from Late Cretaceous of Mongolia. Our study suggests a probably endogenous source of the iron related to hemoglobin. We etched bone material using EDTA and nitric acid to remove the bone phosphate matrix and to leave only the ferruginous compounds. The obtained material exhibits micrometer-sized structures, interpreted as blood vessel fragments, osteocytes, and possibly blood cells. These materials were initially investigated with light microscopy and SEM. Further EDS, Raman, and Mössbauer spectroscopies provided a detailed chemical and mineralogical characterization of the samples. The result of the Mössbauer analysis shows four magnetic Fe³⁺ sites and three non-magnetic, Fe³⁺ and Fe²⁺, sites. The latter sites correspond to oxygenated and deoxygenated hemoglobin. Furthermore, the presence of ferrihydrite points to iron coming from the bone material itself. The presence of goethite, i.e., magnetic Fe³⁺ sites, represents the last, stable stage of iron mobility during the diagenetic pathway. This is visible in the crystallographic properties of the goethite crystals and is also supported by differences in the quality of detailed preservation of biological structures. These observations allow for us to propose a possible route of iron from the biological to geological stage.

Funding Sources This research project is supported by the National Science Centre, Poland, grant no. 2019/32/C/NZ4/00150.

Preparators' Poster Session

BE PREPARED: ADVANTAGES OF IMPLEMENTATION OF SEVERAL FOSSIL PREPARATION TECHNIQUES IN THE PIPESTONE CREEK BONEBED, A CRETACEOUS WAPITI FORMATION LOCALITY

Sweder, Jackson

Philip J Currie Dinosaur Museum, Wembley, Alberta, Canada

The innumerable varieties of fossil preservation types across temporal ranges and cladal groups has necessitated a similar diversity of methods required to prepare and preserve the specimens. Preparation and preservation methods vary according to fossil type (i.e., vertebrate vs. invertebrate vs.

plant), geological age (e.g., Cretaceous vs. Pliocene) and lithology. Every fossil locality, and every species within the locality, varies in how it must be prepared and preserved. Even in a monospecific fossil locality such as a bonebed, preservation varies, and specimens may require unique treatment.

The Pipestone Creek Bonebed (PCB) near Wembley, Alberta, Canada, is a prime example of the variety of preparation techniques that must be employed in the preparation of fossils from a single species and locality. The PCB is a monospecific bonebed of the Late Campanian ceratopsian species, *Pachyrhinosaurus lakustai*. The bonebed deposit extends for an estimated 5000 m² in a nearly flat layer 10 m above its namesake, Pipestone Creek. To date, an approximate 4,000 fossils have been collected from a 50 m² area, and *Pachyrhinosaurus lakustai* makes up approximately 95% of the vertebrate skeletal material identified.

Despite the incredible density of this bonebed and its monospecific nature, preservation and subsequent preparation of fossils are not comparable across all specimens collected. Preservation can vary between adjacent bones and even across a single bone, and the preparation of the specimen must vary accordingly. The fossils from the PCB are most often prepared using a variety of manual techniques involving small hand tools (i.e., carbide pins, scalpels, dental picks, wire brushes) and pneumatic air scribes. The use of a variety of tools and the associated skills required to employ them has highlighted the advantages of preparators of PCB material being trained and practiced in a variety of preparation methods. Case studies of these fossil preparations from the PCB demonstrate the importance of preparators being knowledgeable in a variety of tools and techniques and to be flexible and adaptable in how and when they are implemented.

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

REVISITING THE *STEGODON* OF LUZON, PHILIPPINES – INSIGHTS FROM NEW FOSSIL MATERIAL

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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* 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

Technical Session 14: Squamates & Turtles (Friday, November 4, 2022, 1:45 PM)

CEPHALIC VASCULATURE OF EXTANT TURTLES: THEIR THERMAL PHYSIOLOGY AND ITS EVOLUTIONARY IMPLICATIONS

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Although turtles are characterized by numerous morphological features unique among reptiles, evolutionary origins and changes of such features, especially soft-tissue structures, along their fossil lineage have not been fully explored. Now that results of morphological and molecular phylogenetic analyses have converged to suggest that turtles are crown diapsids, reconstruction of soft-tissue anatomy in early-diverging fossil forms is highly relevant to elucidating the

evolutionary history of Diapsida. Such reconstructions, however, require information on extant turtles. We herein focused on the cephalic vasculature. Although the cephalic vasculature is important in moderating temperatures of neurosensory tissues, detailed information of anatomy and osteological correlates of this system is seriously lacking both in fossil and extant turtles. In this study, three species of turtles (*Chelonia mydas*, *Chelydra serpentina*, *Trachemys scripta*) were examined using vascular injection, μ CT scanning, and gross dissection. Although these turtles had a cephalic vascular pattern generally similar to that of lepidosaurs, they still had the following notable characteristics: (1) the superior alveolar artery extending has a different course through the maxilla than in lepidosaurs and crocodiles; (2) the inframaxillary artery has a significant contribution into the nasal region; (3) the orbital venous sinus and anatomical apparatus for establishing a brain-to-body temperature differential is similar to the possibly plesiomorphic condition observed in lepidosaurs.

These results have evolutionary implications of turtles and other diapsids. The vessels mentioned above produce osteological correlates that are useful for inferring the evolutionary sequence in rostral anatomy by taking the fossil records into account. In particular, the osteological correlate of the inframaxillary artery, which might be important for heat exchange in the nasal region, was found in *Proganochelys quenstedti* from the Triassic, indicating that the arrangement of the blood vessels in the rostral region of extant turtles was likely to be established at an early stage of stem-turtles. In addition, it may be hypothesized that the loss of the orbital sinus and hence the adoption of the alternative thermoregulation apparatus for neurosensory tissues occurred in Archosauromorpha after the clade toward turtles diverged, if the archosauromorph affinities of turtles are accepted.

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Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

DIET-STOMACH INTERACTION AMONG NEORNITHINES AND ITS IMPACT ON THE NEORNITHINE EVOLUTIONARY HISTORY

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The dietary ecology of organisms is under strong selection pressure due to the tight link to individual fitness. Neornithine (i.e., crown birds) is a classic example for investigating dietary adaptations. Previous studies intensively focus on diet-beak morphology interactions. Neornithine stomachs, a functional analog of mammalian teeth, are also a key digestive apparatus. This study thus evaluates neornithine stomach variations and

elucidates diet-stomach morphology relationships to infer the impacts of the neornithine stomach on their evolutionary history.

We dissected 368 neornithine stomachs covering the major neornithine orders. Our results identified four stomach morphotypes that vary in muscular wall thickness and stomach configurations. These morphotypes are associated with dietary specialists. Plant + seed specialists are strictly limited to the muscular stomach morphotype, and vertebrate specialists are represented by the morphotypes with a large lumen. Mapping stomach morphotypes and diets on the phylogenetic trees reveals a strong phylogenetic constraint on stomach morphotypes and less constraint on dietary ecology. The ancestral state reconstructions indicate that the stomach morphotype diversification preceded the appearances of the plant + seed and vertebrate specialists. The muscular stomach is likely to be mandatory to be specialized for plant + seed feeding since the stomach is the only place for mechanically processing ingesta. In contrast, the acquisitions of large lumen for food storage might have allowed neornithines specialized for vertebrate feeding by enabling whole swallowing ecology.

The ancestral state reconstructions further suggest that the neornithine ancestor had the most muscular stomach morphotype, which is the only morphotype that includes plant + seed specialists. This result is congruent with the fact that some non-neornithine avialans (e.g., *Sapeornis*) had a seed-eating behavior. Recently, seed-eating ecology has been suggested to be critical for surviving K/Pg extinction. Given that the clades with muscular stomachs (i.e., Galloanserae and Palaeognathae) survived the K/Pg extinction, our work may suggest that the muscular stomach acquisition during the Cretaceous was the key to Neornithine survival through the K/Pg extinction.

Funding Sources Grant-in-Aid for JSPS Research Fellow (Grant Number 17J06410)

Technical Session 13: Early Archosaurs & Pterosaurs (Friday, November 4, 2022, 1:45 PM)

A MIDDLE TRIASSIC BONEBED WITH AQUATIC AND TERRESTRIAL VERTEBRATES IN MIEDARY, POLAND

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The Middle Triassic was a crucial period of the origination and radiation of numerous vertebrate lineages. However, outcrops of sediments of this age yielding remains of terrestrial animals are rare. One such locality was discovered recently in Miedary (Silesia, southern Poland). The Ladinian strata (lowermost Keuper) exposed there contain abundant and

sometimes articulated remains of various vertebrates, both terrestrial and aquatic, frequently preserved three-dimensionally.

We have collected several thousand macroscopic specimens, making the Miedary bonebed one of the richest vertebrate-yielding outcrops in the European Triassic. Among the recognized taxa, there are several species of elasmobranchs and actinopterygians, the dipnoan *Ptychoceratodus* sp., capitosaur *Mastodonsaurus* sp., three plagiosaurid species, the chroniosuchian *Bystrowiella* sp., nothosaurid *Nothosaurus* sp., tanystropheid *Tanystropheus* sp., archosauriforms (represented by six tooth morphotypes), and a new enigmatic archosauromorph.

The Miedary fauna resembles those from the Middle Triassic of Germany, but with some essential differences. The assemblage contains taxa usually related with saline environments as well as those typically found in freshwater settings. However, original coexistence of both of these groups in a brackish reservoir cannot be excluded. It is noteworthy that the assemblage also comprises rare remains of terrestrial animals. The richness of animal remains in Miedary enables future detailed studies on osteology, taphonomy, intraspecific variability, pathologies, and functional anatomy.

Funding Sources This project is supported by the National Science Centre, Poland, grants no. 2019/35/N/NZ8/03806 (awarded to L. Czepinski) and 2017/27/B/NZ8/01543 (awarded to T. Sulej).

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

A DIVERSE DINOSAUR EGG ASSEMBLAGE FROM THE MID-CRETACEOUS JINHUA FORMATION, ZHEJIANG PROVINCE, CHINA

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Although dinosaur skeletal remains are rarely found in the Jinhua Formation (lower Upper Cretaceous) of the Jinqu Basin in Zhejiang Province, China, this formation has produced a large number of dinosaur eggs. Only partial skeletons of sauropods (*Dongyangosaurus* and *Jiangshangosaurus*) have been recognized from the formation; thus, the eggs are a primary source of evidence for dinosaur diversity in the region at that time. To date, eggs of four oofamilies have been identified or briefly described (i.e., Dendroolithidae, Dongyangoolithidae, Faveoololithidae, and Spheroolithidae), but most of the eggs recovered have yet to be studied. In this

study, we examine and classify over 450 isolated eggs and 11 partial clutches from the Jinhua Formation in order to assess dinosaur diversity. Macro- and microscopic observations revealed that these eggs and clutches are assignable to at least 11 morphotypes: Dendroolithidae (two morphotypes), Dictyoolithidae, Faveoololithidae, Macroelongatoolithidae, Ovaloolithidae (two morphotypes), Spheroolithidae (two morphotypes), Stalicolithidae, as well as a small unclassified avian or non-avian theropod egg. Including previous identifications, a total of 12–15 ootaxa are now recognized from the formation, suggesting a considerably higher diversity of dinosaurs than indicated previously by eggs and/or skeletons. These ootaxa also indicate that the eggs were likely laid by hadrosaurs (or other ornithomimids), sauropods, and various theropods, including therizinosaurs, large oviraptorosaurs, and small maniraptorans or birds. This research represents the first comprehensive analysis of dinosaur eggs from the Jinhua Formation, revealing a diverse dinosaur fauna from the region that is largely unknown from skeletal remains.

Funding Sources JSPS KAKENHI Grant Number JP19K23453 to K.T.

Virtual Posters

A NEW SMALL HESPERORNITHIFORMES FROM THE SMOKY HILL MEMBER OF THE NIOBRARA FORMATION IN WESTERN KANSAS

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Hesperornithiforms are toothed foot-propelled diving seabirds that inhabited the Northern Hemisphere during the Late Cretaceous, best known from the Western Interior Seaway (WIS) in North America. We describe herein a new small hesperornithiform (YPM VP.001467) from the Smoky Hill Member of the Niobrara Formation (Late Coniacian to Early Campanian) in western Kansas. The specimen was collected by E. W. Guild for O. C. Marsh in 1879 and was originally identified by Marsh as a young individual of *Baptornis advenus*. YPM VP.001467 consists of the distal part of the right femur, an almost complete tibiotarsus, the proximal end of the fibula, and the proximal right tarsals that are not fused completely with the tibial shaft, evidence for it being an immature individual. Also suggesting its young age are the relatively smooth bone surface textures and the non-porous epiphyses, indicating that YPM VP.001467 was not a chick but rather a juvenile or subadult.

Our phylogenetic analysis suggests YPM VP.001467 is more derived than *Baptornis advenus* and *Fumicollis hoffmani* and more basal than Hesperornithidae (*Parahesperornis alexi* + *Hesperornis* spp.). In addition, YPM VP.001467 has a mosaic combination of primitive (e.g., slender femoral outline) and derived (e.g., well-defined tubercles of the medial margin of the femoral shaft and a pocket-shaped patellar groove) hesperornithiform characters, showing a transitional morphology between non-hesperornithid hesperornithiforms and hesperornithids. And morphological comparison with a young hesperornithid femur (YPM VPPU.022406) from the Mesaverde Formation of Wyoming indicates that YPM VP.001467 is not an immature individual of the Hesperornithidae but rather a new taxon.

Based on femoral circumference, the estimated body mass (EBM) of YPM VP.001467 is 4.7 kg, about 60%, 55%, and 8% of that of *Fumicollis hoffmanni*, *Parahesperornis alexi*, and *Hesperornis regalis*, respectively, thus making it the smallest hesperornithiform known from the Niobrara Formation. Our analyses of EBM distribution of Hesperornithiformes in Kansas, South Dakota, Manitoba, and the Northwest Territories found that EBM ranged widely in each region and showed no correlation between body size and latitude in hesperornithiform distribution. We thus propose that Hesperornithiformes had a high degree of inter-specific niche partitioning across an extensive area from the middle to high latitudes of the WIS during the Late Coniacian to Campanian.

Virtual Posters

CHEMICAL PRESERVATION OF A PELAGORNITHID MANDIBLE FROM THE OLIGOCENE KISHIMA GROUP, SOUTHWESTERN JAPAN

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The Paleogene groups are widely distributed in northern Kyushu Island, southwestern Japan. Among these groups, the Oligocene Kishima Group in northwestern Kyushu Island yielded only a few vertebrate fossils including pelagornithid, pterosaur, and turtle specimens to date. Left partial mandible of a pelagornithid was recovered from a siltstone layer of the Kishima Formation, the lowermost formation of the group yielding marine mollusk fossils. It is 86 mm in length as preserved. To understand the chemical preservation of vertebrate fossils from the Kishima Group, elemental distribution pattern of this specimen was examined using non-destructive X-ray fluorescence analysis. The same analyses were conducted with modern avian mandibles for comparison with the fossil specimen.

The results show that the pelagornithid mandible contains more major elements aluminium, silicon, and iron, and trace elements strontium, yttrium, and sulfur than modern specimens, whereas value of zinc is lower in the fossil specimen. Within the pelagornithid mandible, the elemental distribution differs in vivid contrast between the internal and external regions. The internal region where osteofibrous structure can be recognized contains major elements phosphorus and calcium, which are slightly less than modern specimens and more than the external region in mass percentage. The outer region of the mandibular shaft with smooth surface has higher percentage of major elements magnesium, aluminium, silicon, and iron than in the internal region. At the base of pseudoteeth, values of trace elements nickel, copper, and strontium are higher than the internal region as well as external region of the mandibular shaft. It is interpreted here that elements whose values are higher in the fossil specimen were incorporated into the specimen during fossilization, typically in its external region. In the internal region, however, much less incorporation of non-biogenic elements took place. Calcium is partially substituted by strontium and yttrium. Finally, this fossil specimen is characterized by the high iron concentration on its surface.

Funding Sources This work was supported by JSPS KAKENHI Grant Number JP18K03828.

Technical Session 4: Paleobiogeography (Wednesday, November 2, 2022, 1:45 PM)

FOSSILS FOR THE FUTURE: USING WALRUS PALEODISTRIBUTION TO PREDICT THEIR RESPONSE TO ANTHROPOGENIC CLIMATE CHANGE

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The construction of ecological niche models, or ENMs, generally relies on records of current organismal distribution. Modern occurrence data, however, are not necessarily representative of the whole range of environmental conditions within which an organism can thrive, also known as its fundamental niche. This limitation restricts the utility of ENMs for predicting how species will respond to anthropogenic climate change. The fossil record offers an opportunity to improve our understanding of the fundamental niche of studied organisms to better inform range shift predictions and associated conservation policies. In this study, I constructed two sets of ENMs using the modern and fossil distributions of the walrus *Odobenus rosmarus*, a species whose range is expected to change drastically with the rapid warming of the Arctic. With presence records downloaded from the Global Biodiversity Information Facility and the Paleobiology Database, I used the MaxEnt algorithm to predict the range of *O. rosmarus* by the year 2100 under the RCP 4.5 and RCP 8.5 climate scenarios. The model built from

modern data forecast an almost complete loss of habitable environments for *O. rosmarus* under both climate scenarios by 2100. The fossil model, on the other hand, identified several areas where walruses could persist even under the most extreme climate predictions, including parts of Hudson Bay, the Gulf of Boothia, and Queen Maud Gulf in North America, and the East Siberian Sea, Laptev Sea, and Kara Sea in Russia. This study not only highlights areas of particular conservation importance for the walrus but also emphasizes the importance of considering fossil distributions as well as modern ranges when constructing predictive ENMs.

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

MORPHOLOGY AND ARTICULAR CONFIGURATION OF THE TARSUS IN CERATOPSID DINOSAURS AS REVEALED BY A COMPLETE LOWER HINDLIMB FROM THE BELLY RIVER GROUP OF SOUTHERN ALBERTA, CANADA

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Like other postcranial elements, the hindlimb of ceratopsid dinosaurs has received little attention, as workers have tended to focus on skull bones. This is even more so for tarsal elements specifically. Descriptions of hindlimb material that do exist rarely describe complete specimens in detail, resulting in confusion about tarsal morphology and articulation and limiting their utility in biomechanical studies. UALVP (University of Alberta Laboratory for Vertebrate Palaeontology) 42, a complete ceratopsid left lower hindlimb collected from the Belly River Group of southern Alberta, Canada by George F. Sternberg in 1920, is a good candidate for detailed study of ceratopsid tarsals. While UALVP 42 is taxonomically indeterminate below Ceratopsidae, the distally expanded lateral malleolus on a robust tibia, 4 functional digits, and hoof-like unguals confirm it is from a ceratopsid. All elements distal to the knee are present, including the tarsals, but some elements are incomplete and partially reconstructed. UALVP 42 was CT scanned using a Siemens Somatom Definition Flash scanner and segmented digital models of the genuine fossil material were used to describe the bones and create a 3D model of the articulated distal hindlimb. Parts of both ends of the tibia proved heavily reconstructed, but other elements, such as the tarsals, are largely genuine. Varying numbers of distal tarsals are reported for ceratopsids, but UALVP 42 definitely has two distal tarsals. This may be typical, or the number of distal tarsals may vary with species or degree of ossification. In UALVP 42 each distal tarsal has one strongly convex side and one concave side. While the proximal surfaces of the distal tarsals are reportedly concave in the basal ceratopsians *Protoceratops* and *Leptoceratops* and in indeterminate juvenile centrosaurine material from “*Brachyceratops*”, these surfaces are convex in UALVP 52613, an articulated juvenile *Chasmosaurus*. We reconstruct

the convex surfaces of the distal tarsals as proximal in UALVP 42, consistent with UALVP 52613 and with the usual dinosaur condition of concentrating ankle flexibility at the joint between the proximal and distal tarsals. A convex roller surface formed by the distal tarsals opposed a similar roller surface formed by the proximal tarsals and distal end of the tibia, resulting in a highly mobile tarsal articulation. This clarified understanding of ceratopsid tarsals will enable better biomechanical analyses of ceratopsid hindlimbs.

Technical Session 13: Early Archosaurs & Pterosaurs (Friday, November 4, 2022, 1:45 PM)

THE FEATHERED SERPENT DID NOT LIVE IN HELL: REAPPRAISAL OF AN AZHDARCHID CERVICAL VERTEBRA FROM THE HELL CREEK FORMATION OF MONTANA

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A considerable amount of fossil material pertaining to azhdarchid pterosaurs has been recovered from Campanian and Maastrichtian deposits of North America. Historically, many of these specimens have been referred to the genus *Quetzalcoatlus*; however, this was done with preliminary understanding of the taxon's morphology and the diversity of azhdarchids. Following further study of *Quetzalcoatlus* and other azhdarchids, some North American material previously referred to *Quetzalcoatlus* has since been reassigned to other taxa in recent years, including *Cryodrakon boreas* and *Wellnhoferus brevirostris*. A recent exhaustive study of Big Bend pterosaur material has finally elucidated the anatomy of *Quetzalcoatlus* spp., and allows long-overdue reappraisals of other North American azhdarchid material previously referred to the genus.

In 2002, a laterally compressed but nearly complete azhdarchid fifth cervical vertebra (BMR P2002.2) was recovered from an outcrop of the Hell Creek Formation in Carter County, Montana, and provisionally referred to cf. *Quetzalcoatlus*. Digitization of this specimen via laser scanning allows a more detailed assessment of this specimen's morphology, revealing a combination of characters not present in the cervical vertebrae of *Quetzalcoatlus* spp. This combination is unique across known azhdarchid fifth cervicals, suggesting that the Hell Creek specimen represents a new medium-sized azhdarchid taxon. Phylogenetic analysis recovers this taxon forming a clade with *Arambourgia* to the exclusion of other named quetzalcoatlines, and suggests that there is no evidence for the presence of *Quetzalcoatlus* outside of the Javelina Formation of Texas. Reappraisal of this specimen and other contemporary azhdarchid material reveals a high but cryptic diversity of azhdarchids in Maastrichtian

North America, with at minimum five distinct species being identifiable. Recognition of this specimen as a distinct taxon highlights the importance of revisiting prior taxonomic assignments of geographically and stratigraphically disparate material in the wake of newer discoveries and studies.

Technical Session 16: Hoofed Mammals (Saturday, November 5, 2022, 8:00 AM)

THE LAST KNOWN PALAEOOTHERE: CONTRIBUTIONS OF NEWLY DISCOVERED REMAINS AND ENDOCRANIAL CHARACTERS TO THE PALAEOECOLOGY AND RECONSTRUCTION OF *PLAGIOLOPHUS HUERZELERI* (MAMMALIA, PERISSODACTYLA)

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The Palaeotheriidae are a group of perissodactyls (the "odd-toed ungulates") endemic to Europe that have long been considered closely related to the Equoidea. However, recent phylogenies suggest that they may not only be paraphyletic, but also more derived than Equoidea, and distant to them. In addition, whereas equoids survived and diversified during the Oligocene in North America, the "Palaeotheriidae" went almost extinct after the Eocene-Oligocene transition, i.e. the Grande Coupure event. Among the few surviving genera of this European crisis, the genus *Plagiolophus* survived for about 3 million years, until the extinction of *P. huerzeleri*, the last representative of all "Palaeotheriidae".

This species was discovered only two decades ago from the early Oligocene locality of Murs (Vaucluse, France). Its description was based on partially unprepared cranial specimens and very sporadic postcranial remains: two astragals, four calcanei and one MtIII. Although the remains had been discovered more than a hundred years ago, they had never been studied until then, and the locality of Murs fell into oblivion.

Today, after several years of recurrent excavations in this rediscovered locality, four new skulls of *Plagiolophus huerzeleri* have been found, and its postcranial skeleton is now almost completely known. In addition, the historical unprepared specimens have now been fully extracted from their matrix and restored. One skull has been CT-scanned, revealing its internal anatomy for the first time and notably, its petrosal bone and inner ear. All specimens are deposited in two institutions: the Parc naturel régional du Luberon (Apt, France), housing the recently excavated remains, and the Naturhistorisches Museum Basel (Switzerland), housing the

historical specimens.

Thanks to the exceptional richness of this locality, we can now propose the first anatomically accurate reconstruction of *Plagiolophus* and have a better understanding of its palaeoecology. This anatomical reconstruction was made from 3D models of all known postcranial remains, using a surface scanner. Based on this reconstruction, although *Plagiolophus* may superficially look like an equoid (by convergence), many differences underscore their distant relationship.

Finally, in addition to the abundant remains of *Plagiolophus*, numerous other groups, including mammals, crocodiles, turtles, fishes and birds, depicting a rich and diverse palaeoenvironment were also discovered in the locality of Murs.

Funding Sources This project was financially supported by the Swiss National Science Foundation (SNF projects 200021_162359 and 199605).

Technical Session 2: Paleocology (Wednesday, November 2, 2022, 8:00 AM)

MACROEVOLUTIONARY DYNAMICS OF DIET IN AMNIOTES

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Dietary evolution has profoundly impacted the evolution of amniotes and the ecosystems they inhabit. Amniotes are ancestrally faunivorous and herbivory has evolved multiple times independently. However, “carnivory” (of vertebrate carrion) and “herbivory” (of vegetative plant structures) are end-members of a multidimensional dietary spectrum, spanning varying types and proportions of plant and animal food. To test how a taxon’s position on this spectrum relates to other life history traits in a macroevolutionary framework, we compiled new, broadly sampled datasets of diet, body size, and foraging strategy for most extant turtles (268) and lizards (5265), and integrated existing datasets for birds (9993) and mammals (5242), quantifying each species’ diet as a percentage of total food consumption in different food categories. We use cluster analyses of these data to develop new, more nuanced, dietary guilds and existing, large amniote phylogenies to test the following hypotheses and assumptions: (1) the nature of the relationship between body size and dietary categories; (2) the polarity and pace of evolutionary transitions into specialised herbivory and carnivory; (3) the plasticity of feeding strategies; (4) the relationship between extinction risk and dietary specialization; and (5) the relationship between taxonomic diversity and dietary shifts.

We find that: (1) increased consumption of vegetative plant

structures or carnivory, when considered independently of other variables, have little predictive power for body mass in extant amniotes, (2) transitions into hyperspecialized forms of herbivory and carnivory, and into generalist omnivory (including a relatively even spread in the dietary intake of both plant and animal food sources), occur more frequently than the converse, (3) feeding strategies involving reproductive plant structures and invertebrates are more plastic than other food categories, (4) taxa with omnivorous, and plant-dominated feeding strategies have higher risks of extinction than those with animal-dominated feeding strategies, (5) across the tree, dietary shifts into herbivory and carnivory tend to be concentrated, shifts to increased plant consumption are dispersed, and neither of has a meaningful impact on lineage density. The results of our analyses using this more nuanced understanding of diet will be extrapolated onto fossil datasets allowing us to rethink the evolutionary dynamics of shifts in dietary strategy through deep time.

Funding Sources National Research Foundation of South Africa (NRF), grant reference number: MND200718544868.

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

GONDWANAN THEROPOD DINOSAURS IN THE CENOMANIAN OF SOUTHWESTERN EUROPE

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Algora paleontological site is one of the best localities to characterize the Cenomanian fauna in southwestern Europe. The site has yielded the largest concentration of vertebrate macroremains for this age and area. Considering the geographical situation of the Iberian Peninsula at that time, Algora provides relevant data to better understand the paleobiogeography and the transition between the Lower and the Upper Cretaceous faunas of Europe, and also the interfaunal changes between Gondwana and Laurasia. Thus, several representatives of lineages typical from Laurasia have been recognized in the site (e.g., helochelydid turtles), but also others with a Gondwanan origin (e.g. bothremydids or the lepisosteid fish *Obaichthys africanus*). Regarding theropod remains, isolated teeth are the most abundant fossils of this group in Algora. During the last field seasons, the finds have noticeably increased the sample, which have allowed us to reanalyze, in detail, the systematic attribution of this lineage of dinosaurs. Qualitative and quantitative analyses have been performed on the sample. All these teeth have a blade-like general shape and possess denticles on both carinae. Posterior denticle density varies between 2 and 3 denticles per mm and the anterior denticle density varies between 2.5 and 3 mm. Denticle shape is rectangular in all cases. It is possible to observe enamel wrinkles in some of the teeth although

although some preservation problems makes difficult to observe this feature in all the sample. The teeth show a cross section between lanceolate and D-shaped, which is characteristic of lateral abelisaurid teeth. Therefore, their qualitative features are in agreement with an assignment to Abelisauridae although some characteristics such as the presence of flat or concave surfaces near the carina, which is considered a synapomorphy of the ceratosaurians, are not present in Algora teeth. However, the statistical analyses performed on the sample show that Algora teeth are grouped near the abelisaurid teeth from Kem Kem beds and, in the discriminant analyses, Algora sample is mostly assigned to Abelisauridae. Therefore these teeth could belong to an abelisaurid related to a taxon from the Cenomanian of Gondwana, representing a lineage that survived until the uppermost Cretaceous of Europe.

Funding Sources Spanish Ministry of Science and Innovation (PID2019-111488RB-I00) and the Regional Government of Castile-La Mancha (SBPLY/19/180801/000034 and SBPLY/21/180801/000039).

Technical Session 18: Birds (Saturday, November 5, 2022, 1:45 PM)

NEARLY COMPLETE SKULL OF LATEST CRETACEOUS BIRD *VEGAVIS IAII* PROVIDES NEW INSIGHTS ON FEEDING ECOLOGY AND NEUROANATOMY IN EARLY PHASES OF AVIAN CROWN GROUP DIVERSIFICATION

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Fossils representing Cretaceous lineages of extant birds (*Aves*) are exceedingly rare but are nevertheless crucial to elucidating changes in key anatomical systems across early avian divergences, and importantly, transformations at the crown. Among the earliest known putative crown birds is *Vegavis iaai*, a diving form from the latest Cretaceous (69.2–68.4 Ma) of Antarctica with controversial phylogenetic affinities. Initially reported as a stem anatoid (ducks and closely related taxa), *Vegavis* has since been hypothesized to be a stem Anseriformes (waterfowl) or even outside *Aves* altogether. Here, we report a new, nearly complete skull of *Vegavis* that provides new data on its phylogenetic affinities, feeding ecology, and neuroanatomy. The new specimen consists of a mostly complete rostrum, palate, orbital region, neurocranium,

and basicranium, as well as much of the mandible. The rostral margin consists exclusively of the premaxilla, with an extremely reduced maxilla not expressed on the lateral aspect of the upper beak, strongly supporting an assignment to the avian crown. Additionally, *Vegavis* has a brain shape characteristic of crown birds (i.e., a relatively expanded cerebrum, ventrally-positioned optic lobes, and a low, broad wulst). The new specimen displays the specific bicondylar craniomandibular articulation previously reported in *Vegavis* and consistent with placement within Galloanserae. Moreover, morphologies of both the vomer and basipterygoid articulation, as well as the expansive temporal fossa, are more like Anseriformes than Galliformes (landfowl). *Vegavis* exhibits morphologies of the feeding apparatus that are apparently unique among crown birds, including a bipartite conformation of the temporal fossa and a caudally-reinforced craniomandibular joint. These new data underscore *Vegavis* as an early experiment in the evolution of a diving lifestyle in the avian crown during the latest Cretaceous, prefiguring much of the aquatic bird diversity we see in the world today.

Funding Sources National Science Foundation: ANT-0636639, ANT-1142104, ANT-1142129 and ANT-1141820

Technical Session 4: Paleobiogeography (Wednesday, November 2, 2022, 1:45 PM)

CONTINENTAL GIGANTISM IN A PLEISTOCENE TORTOISE FROM ECUADOR RAISES QUESTIONS REGARDING THE DEEP HISTORY OF THE GALAPAGOS LINEAGE

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Tortoises (*Testudinidae*) are estimated to have arrived in South America during the early Miocene (~23 Ma), a time before the formation of the Panama Isthmus when ocean currents were conducive to emigration from Africa via long-distance drifting. The subsequent endemic radiation is classified within *Chelonoidis*. On one side of this crown clade is the extant red- and yellow-footed tortoises, *C. carbonarius* and *C. denticulata*, respectively. On the other side is the Chaco tortoise, *C. chilensis*, and ~12 species of giant Galapagos tortoises. Although *C. denticulata* is large, gigantism among the living forms is restricted to the Galapagos clade. This pattern supports the hypothesis that the ancestor of the Galapagos total group was relatively small and that gigantism here represents a single evolutionary event, one likely driven by the famously unique dynamics of island populations. Parallel hypotheses exist in other tortoise lineages and other island systems (e.g., *Aldabrachelys gigantea*). We describe a small collection of specimens from the Tablazo Formation (late Pleistocene, ~12Ka), Santa Elena Province, Ecuador that at least raises the possibility that this well-

accepted narrative for the origin of the Galapagos tortoise may be overly simplistic.

The specimens are not well preserved, representing only isolated and fragmentary portions of shell. We assessed support for their phylogenetic relationships, but a robust, well-resolved tree remains beyond the capability of the current matrix. The new specimens can be unambiguously diagnosed to the *Chelonoidis* total group, and a signal places our specimens on the *chilensis*-Galapagos side of the *Chelonoidis* crown group. Intriguingly, the specimens are extremely large and indicate a species whose gigantism was on par with that of the Galapagos taxa. Size may itself be a derived character that is uniquely shared between the Ecuador and Galapagos forms, and some of our analyses recover this sister-group relationship. Although phylogenetic resolution will require further investigation and likely additional data, we can report with reasonable certainty that a giant species of Pan-*Chelonoidis* tortoise was living in Ecuador only slightly after the inferred arrival of the Galapagos lineage in the archipelago. We discuss the various hypothesis that might explain this set of facts, including the possibility that the Galapagos lineage was giant before it left the South American mainland.

Technical Session 10: Soft Tissues & Taphonomy (Friday, November 4, 2022, 8:00 AM)

QUANTITATIVE RECONSTRUCTION OF CARTILAGINOUS COMPONENTS OF THE SAUROPOD HINDLIMB MODULE: EVOLUTIONARY TRANSITIONS AND FUNCTIONAL SIGNIFICANCE

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Sauropods are characterized by exceptionally massive body size and highly derived appendicular morphologies, in which epiphyseal cartilage contributes to large portions of functional joint shape and muscular attachment surfaces. However, the rarity of cartilage preservation in the fossil record hampers inferences on the evolution of sauropod locomotor biology, such as joint loading, range of motion, and musculoskeletal kinetics. This study investigated the evolutionary transition and functional significance of femoral and pelvic cartilage in sauropodomorphs. We digitized the femora, pelves, and anterior caudal vertebrae of 45 sauropod and outgroup taxa, quantified growth plate rugosities via comparison with artificially “smoothed” subchondral surfaces, inferred growth plate rugosities as osteological correlates for cartilage thickness, and estimated key evolutionary transitions in cartilage morphology using maximum likelihood ancestral state reconstruction. Early sauropodomorphs exhibit an evolutionary trend towards overall thickening of hyaline cartilage at the proximal end of the femur, whereas regionally thickened capitular cartilage first appeared in Eusauropoda. Compared to macronarians, diplodocoids possess flatter

capitular subchondral surfaces, deeper rugosities, and more distinct metaphyseal collars, indicating greater contribution of both hyaline cartilage and fibrocartilage in forming the functional femoral head. Both diplodocoids and derived titanosaurs convergently evolved dorsoventrally expanded transverse processes on the anterior caudal vertebrae, suggesting the presence of massive cartilaginous shelves that expanded the ilial blade caudally, buttressed by the anterior caudal transverse processes. The anterior caudal vertebrae are therefore incorporated into the functional sacrum as ‘cryptic sacral’. This novel interpretation of the pelvic skeleton challenges traditional anatomical reconstruction of the sauropod hindlimb module and suggest a greater degree of functional integration between the hips and tail.

Funding Sources HPT is supported by the Southern Connecticut State University Faculty Startup Fund. CTG is supported by the NSF Postdoctoral Research Fellowship in Biology.

Virtual Posters

A NEW SPECIMEN OF THE SUIDAE (MAMMALIA, ARTIODACTYLA) FROM THE UPPER MIOCENE OF JAPAN, AND A BRIEF REVIEW OF JAPANESE NEOGENE SUIDS

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Wild boars, *Sus scrofa* (Mammalia, Artiodactyla, Suidae), currently live widely in the Japanese Islands, except for Hokkaido Region, which is the northernmost part of Japan. Suid fossils and relics in Japan are well known and collected in Quaternary sediments, but they are rarely found in Neogene-aged deposits. In the upper Miocene of Japan, only one fragmentary upper molar has been reported from the Oiso Formation (*ca.* 8.29–5.57 Ma) of the Miura Group, Kanagawa Prefecture.

Here, we report an additional specimen of Suidae discovered in the Oiso Formation. The specimen is a left m3, and its hypoconulid is broken away. It is bunodont and low-crowned, and is moderately-to-heavily worn. This m3 has a typical lower molar morphology of a medium-sized suid with furrows on the cusps. The ‘cristid obliqua’ (= merged hypoconid and median accessory cusp due to the wear) is comparable to that of the Suinae, and is longer and extends less diagonally than that seen in the Asian Tetraconodontinae. On the basis of its size and observable morphology, this m3 is most comparable to that of *Propotamochoerus hyotherioides* (Suinae) among Asian Neogene suids. The previously described suid upper molar fragment from the formation appears to belong to the same species as this m3 and seems to be M2. In the Neogene of Japan, only seven (one early Miocene, one early/middle Miocene, one middle Miocene, two late Miocene, and two

Pliocene) suid specimens have so far been reported. Among them, two Miocene specimens are currently missing, one of the Pliocene specimens is in a private collection, and the repository of the other Pliocene specimen is unknown.

Funding Sources JSPS KAKENHI Grant Number 18H01327 (to Naoko Egi).

Technical Session 10: Soft Tissues & Taphonomy (Friday, November 4, 2022, 8:00 AM)

A MYSTERIOUS CLUTCH OF ALTERED DINOSAUR EGGS FROM THE TWO MEDICINE FORMATION OF MONTANA

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The Two Medicine Formation of Montana is known for producing both clutches of dinosaur eggs and isolated fragments of eggshell. Preservation of these eggs ranges from *Maiasaura* and *Troodon* nests with both eggs and perinatal bones to partially dissolved isolated eggshell fragments. A recently collected clutch of eggs (MOR 11881) does not match any of the eggs from the eight oogenera found previously in the formation. Both the eggs themselves and their preservation are unusual with both altered eggshell and soft tissue preservation in the form of an eggshell membrane. The clutch consists of approximately ten slightly oval eggs arranged similarly to hadrosaur (*Spheroolithus*) eggs. Surface ornamentation is only visible under a dissecting microscope but is unlike that seen in *Spheroolithus*, *Tubercuoolithus* or *Triprismatoolithus*. The size and shape of the eggs are variable due to their sub-three-dimensional preservation and the distortion of the egg's shape from crushing. Despite the distortion, the eggs are ellipsoidal in bottom view with the longer axis ranging from 14.5cm to 18.8cm. For their size they have very thin eggshell at around 0.4mm thick. Thin section analysis was used for initial observations of shell structure and egg contents. This analysis revealed both the shell membrane and that the eggshell is altered. The shell membrane in thin section is a dark layered structure that further analysis with Energy Dispersive X-ray (EDX) analysis revealed is rich in phosphate. Scanning electron microscopy (SEM) of the eggshell shows no clear layers or textures normally found in eggshell calcite. In thin section the interiors of the eggs are filled with a mix of sparry calcite, collophane, iron minerals, several types of tiny coprolites, silt and clay from the surrounding sediments. The presence of both coprolites and eggshell membrane suggests that the preservation environment was unique with rapid mineralization while being open to small scavengers (probably insects) for a period of time. Understanding the taphonomy of this clutch will help to better understand the Two Medicine Formation as a nesting site and the environments that dinosaurs nested in.

Funding Sources Paleontological Society Student Research Award

Technical Session 17: Fish (Saturday, November 5, 2022, 8:00 AM)

NEW INSIGHTS INTO EXCEPTIONALLY PRESERVED LATE JURASSIC HOLOMORPHIC RAYS (CHONDRICHTHYES, BATOMORPHI) FROM EUROPE (SOLNHOFEN, CERIN, KIMMERIDGE)

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The fossil record of cartilaginous fishes consists largely of isolated teeth, with holomorphic fossil specimens being extraordinary exceptions. Several deposits from the Late Jurassic of Europe yielded diverse assemblages of fossil cartilaginous fishes to date, with an abundance of more or less completely preserved skeletons that allow us to analyze their morphology in detail. The oldest articulated skeletons of rays, the most diverse group of cartilaginous fishes today, are also known from these deposits. About 150 million years ago, the diversity of these dorso-ventrally flattened fishes was much lower and included only few guitarfish-like species, most of which are only represented by isolated teeth, while the four taxa *Asterodermus platypterus*, *Belemnobatis sismondae*, *Kimmerobatis etchesi*, and *Spathobatis bugesiacus* are known from skeletal remains. Even though several well-preserved specimens have been found that exhibit abundant morphological features, only few studies on these fishes were conducted. These have focused mainly on tooth morphologies, which are extremely similar across species. Therefore, they are not useful for resolving some taxonomic uncertainties, such as the validity of the first described holomorphic ray species, *Asterodermus platypterus*, whose holotype lacks the cephalic region and thus tooth-related diagnostic features. Here, we applied various methods, including traditional and geometric morphometrics, to more than 20 ray specimens from the Late Jurassic of southern Germany (Solnhofen), France (Cerin), and the United Kingdom (Kimmeridge) to resolve the phylogenetic and taxonomic uncertainties associated with Late Jurassic rays. Our results confirm the validity of *Kimmerobatis etchesi* and the most distinct species *Belemnobatis sismondae*. Also, *Asterodermus platypterus* cannot be differentiated from the other ray species by its preserved body outline and proportions. Furthermore, our results indicate that the diversity of rays during the Late Jurassic appears to have been greater than previously thought, as different specimens that have been referred to as *Spathobatis bugesiacus* exhibit markedly different skeletal characteristics. We further discuss differences in species composition across deposits. This study therefore represents the most detailed revision of the oldest holomorphic rays, focusing on body outlines and skeletal features as a

complement to dental morphology to clarify their taxonomic identities and relationships.

Funding Sources This research was funded in whole by the Austrian Science Fund (FWF) P33820.

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

TURTLE AND THEROPOD EGGSHELLS FROM THE HAUTERIVIAN TO BARREMIAN OF OKURODANI FORMATION, NORTHERN CENTRAL JAPAN

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The Lower Cretaceous (Hauterivian to Barremian) Okurodani Formation of the Tetori Group, distributed in the Shokawa area, Gifu Prefecture, northern central Japan, yields various vertebrate remains, such as aquatic fish, cryptodiran turtles, and ornithischian and theropod dinosaurs. From 1988 to 2009, fossils of seven eggshell fragments and six eggshell impressions, denoting hitherto the oldest record of fossil eggshells in Japan, were discovered by three amateur collectors. These specimens however remained unstudied. Here, we examine these specimens and discuss the eggshell diversity in the region.

Microscopic observations led us to classify these eggshells into at least two oofamilies: Testudoolithidae and Prismatoolithidae. The testudoolithid eggshells include two fragments (< 6 mm) characterized by a distinct shell unit of needle-like crystals. The microstructure and estimated egg mass suggest that their parental species are small non-marine turtles. The prismatoolithid eggshells on the other hand include five fragments and four outer surface impressions (< 17 mm). The cross-sections show two structural layers and a columnar extinction pattern under polarized light microscopy. Remarkably, their outer surface bears reticulate ornamentation which distinguishes them from any other prismatic ootaxa. While earlier studies suggest that prismatic eggshells can be ascribed either to troodontid or avian, our phylogenetic analyses placed these specimens outside an avian ooclade, indicating their taxonomic affinity to troodontid or closely related non-avian maniraptorans. This species is inferred to be small-bodied (12–17 kg) based on the estimated egg size. Finally, the other two specimens (< 7 mm) are impressions of eggshell outer and inner surfaces without original fragments, for which taxonomic affinities remain indeterminate as most of the egg characters are unavailable.

Skeletal remains of non-avian theropods laying prismatic eggs (e.g., troodontids) are yet to be reported from the Tetori Group. Thus, these findings on the occurrence of prismatoolithid eggshells from the Okurodani Formation suggest the presence of yet to be identified theropod species, which may add to our further understanding of faunal diversity in this region. Further, the occurrence of small maniraptorans during Hauterivian–Barremian in the easternmost part of Asia greatly extends the confirmed stratigraphic and geographic range of this clade.

Technical Session 19: Marine Mammals (Saturday, November 5, 2022, 1:45 PM)

ASSESSING COMMITMENT TO THE LIFE AQUATIC IN MAMMALS

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Given that all marine mammals are derived from basal tetrapod ancestors that evolved a suite of characteristics to allow them to live and thrive in subaerial instead of subaqueous environments, it is worth exploring how fully, different groups of marine mammals evolved a suite of morphological characteristics to allow them to live and thrive in subaqueous instead of subaerial environments during the reverse transitions. Here I do that by calculating an index of aquatic adaptation that scores taxa for features that indicate adaptation to or use of an aquatic environment, and scales the score between 0 and 1, where 0 would represent no aquatic adaptation (e.g. a cow) and 1 would represent complete aquatic adaptation (e.g. a fish). Scores indicate that no marine mammal has fully re-adapted to aquatic life because all still breath oxygen from air instead of oxygen dissolved in water. That said, Pelagiceti have high scores as do fully aquatic sirenians. Pinnipeds score lower, but above 0.5 because they still reproduce and give birth to their young on land, as well as have the ability to locomote on land. Looking specifically at the evolutionary transitions of each group, in all cases (Cetacea, Sirenia, and Pinnipedimorpha) one can show that the scores start out lower for basal representatives (similar to but often slightly higher than their sister group) and progressively increase in a crownward direction. Both Cetacea and Sirenia take 10–12 Ma to achieve a score equal to those of their respective crown groups, while for Pinnipedimorpha it is around 5 Ma. Marine (or perhaps better said aquatic) mammals outside of these three groups such as Desmostylia, marine & river otters, polar bears, and the aquatic sloth *Thalassocnus* similarly have lower scores (below 0.5) due to their having only minor adaptations (if any outside of behaviors) to an aquatic lifestyle. Some authors have suggested that taxa such as the crab eating macaque (*Macaca fasciculata*) or humans (*Homo sapiens*) should be considered aquatic because they (or some populations) use marine food resources, but this is only one factor of many, and these taxa score near 0. This analysis suggest that future work on aquatic

tetrapods should determine an appropriate level of aquatic adaptation prior to any analysis to ensure that results reflect the true intention of the study, and do not include taxa that are barely aquatic along with those that are maximally aquatic, unless such inclusion is warranted.

Colbert Prize Session

EVOLUTION OF THE PROPATAGIUM IN THEROPOD DINOSAURS: ANALYSES OF ARTICULATED FOSSIL SKELETONS AND EXTANT AVIAN EMBRYOS

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The avian wing is furnished with a highly specialized musculoskeletal system when compared with the forelimbs of other tetrapods. The evolution of this musculoskeletal system involved an establishment of an evolutionary novelty: the propatagium, which accompanies a skeletal muscle spanning between the shoulder and wrist on the leading edge of the wing. However, due to the rarity of the soft-tissue preservation in the fossil record, the evolutionary origin of the avian propatagium has long remained elusive. In this study, we focus on postures of forelimbs preserved in articulated fossil skeletons, assuming that elbow joint angles preserved in fossils are limited to small values in the presence of the propatagium. First, we statistically tested this prediction using data of elbow joint angles preserved in articulated fossil skeletons of crown birds and non-dinosaurian sauropsids. As expected, elbow joint angles of crown bird fossils were significantly smaller than those of non-dinosaurian sauropsids, thereby demonstrating that angles of elbow joints in fossils are indicators of the propatagium. Second, we used this relationship to narrow down the phylogenetic position where the propatagium was acquired in the common ancestor of maniraptorans. Our analyses showed that the preserved propatagium-like soft tissues in the oviraptorosaurian *Caudipteryx* and dromaeosaurian *Microraptor* are homologous with the avian propatagium, and all maniraptoran dinosaurs likely possessed the propatagium even before the origin of flight. Also, we have been investigating the developmental process of the propatagial muscle in the chicken embryo. Unlike the other skeletal muscles of the forelimb, the propatagial muscle develops in association with the hypertrophied dermis along the leading edge of the propatagium, devoid of the interaction with the tendon progenitor cells. Such a hypertrophied dermis was not observed in the other amniote embryos, and likely represents an evolutionary novelty of the lineage towards the birds. Our studies together suggest that the propatagial muscle evolved through a change in embryonic development of the forelimb before the origin of the flight.

Funding Sources JSPS KAKENHI grant no. 19K04061; Sasakawa Scientific Research Grant No. 2022-5036

Technical Session 4: Paleobiogeography (Wednesday, November 2, 2022, 1:45 PM)

HOPPING THROUGH THE ISTHMUS: FOSSIL FROGS AND TOADS FROM THE EARLY MIOCENE CUCARACHA FORMATION OF PANAMA

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Central America is one of the most biodiverse regions and has served as a corridor for biotic interchange for millions of years. The diversity of frogs and toads (Anura) in the Americas was facilitated by and is dependent on the dispersal of species along this corridor, in most cases with different lineages originating in South America and diversifying in Central and North America. Fewer anuran lineages have dispersed in the opposite direction. There are few anuran fossils from this region that are useful for understanding the process and timing of diversification and dispersal events through Central America. To date, only one fossil anuran has been reported (but not described) from the late Miocene of Honduras. Here, we report and describe an anuran fossil community of the early Miocene of Panama. We describe ten humeri from the ~19-million-year-old Cucaracha Formation in the Panama Canal Area. The humeri are grouped into six morphotypes based on the morphological characteristics of the distal condyle and the distal humerus ranges in width from 0.8 mm to 2.6 mm. We compared the fossils with living species from North and Central America (15 families) using 3D models of the humeri based on CT-scans of fluid-preserved specimens. Our comparison indicates that there are at least three families represented in the fossil community of Panama: Eleutherodactylidae, Leptodactylidae, and Bufonidae. These families are broadly distributed and originated in South America at different times in the Cenozoic. Finding these taxa in the early Miocene of Panama demonstrates dispersal of anurans from South to North America before the closure of the Isthmus of Panama, as found in some other vertebrates with South American affinities, such as caimans or boid snakes. Although all terrestrial mammals from the Cucaracha Formation are North American taxa, we have not identified any anuran fossils of taxa that originated in North America. Comparison of these fossil humeri with other South American taxa will help to refine our taxonomic identifications. Future description of other fossil elements and estimations of body size will provide more details on the taxonomic composition and paleoecology of Panamanian anurans in the early Miocene.

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Technical Session 6: Dinosaur Macroecology & Macroevolution (Thursday, November 3, 2022, 1:45 PM)

MAKING A RUN FOR IT: THE IMPACT OF FLIGHT-ADAPTIVE TRAITS ON NICHE PARTITIONING IN CARNIVOROUS NON-AVIAN THEROPODS

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Due to the disparity between infant and adult megatheropod mass, it is likely juvenile megatheropods utilized separate feeding niches through ontogeny. This may have caused dietary overlap with medium sized carnivorous dinosaurs. While many communities lack mesocarnivores, a few species of giant paravians (100-1000kg) did co-occur with megatheropods despite potential competition with juveniles. The traits that enabled giant paravians to compete with megatheropods, the role of ancestral flight-adaptations and whether paravians exhibited the effects of competition are unknown. Here we examine the locomotor capabilities of volant and non-volant paravians and non-paravian theropods across body size to determine top speed and efficiency. We assess prey availability and competitive overlap based on body size and running speed in four dinosaur assemblages containing giant paravians. Finally, we re-examine the phylogenetic placement of the giant paravian *Dakotaraptor steini* to contextualize its competitive capacity. We identify two distinct non-volant paravian cursorial styles: giant paravians had limited top speeds, but were highly efficient runners, while small non-volant paravians were fast, but inefficient. We further find volant paravians among the least adapted to cursorial locomotion. Giant paravians may have competed with megatheropods such as *Tyrannosaurus rex*, and relied on highly efficient locomotion to utilize large hunting ranges.

Technical Session 20: Crocodylomorpha (Saturday, November 5, 2022, 1:45 PM)

A NEW LONG-SNOUDED CROCODYLIAN (CROCODYLIA: GAVIALIDAE) FROM THE EOCENE DOMANDA FORMATION OF PAKISTAN SHEDS LIGHT ON THE EVOLUTIONARY AND PALEOBIOGEOGRAPHIC HISTORY OF GRYPOSUCHINES

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Gryposuchinae is a clade of long-snouted gavialid crocodylians that peaked in diversity during the Miocene. Most fossil gryposuchines have been described from South America, but the subfamily also has been reported from Puerto Rico (*Aktiogavialis puertoricensis*) and Egypt (*Eogavialis africanus*). The latter taxon represents the oldest (~38 Ma) and easternmost occurrence of the clade thus far. Here we report on an even older gryposuchine, recovered from the Eocene (41.5–42.5 Ma) Upper Domanda Formation in Balochistan Province, Pakistan. The new material is represented by a nearly complete skull that preserves most of its rostrum, parts of the orbital region, skull table, teeth, and lower jaws. Postcranial remains include two articulated procoelous dorsal vertebrae, a scapular blade, and the proximal part of the coracoid. Based on the size of the skull and lower jaws, the new material appears to belong to a large individual with an estimated skull length of 100 cm and estimated body length of 6.5 m. Two phylogenetic analyses were carried out to evaluate the evolutionary relationships of the new Pakistani taxon among crocodylians: 1) a parsimony analysis; and 2) a tip-dated Bayesian analysis. The strict consensus tree and the maximum clade credibility tree recovered the new Pakistani taxon deeply nested within Gryposuchinae; the Bayesian analysis had high nodal support (posterior probability = 0.96). These results highlight several fundamental points for understanding the evolutionary history of gryposuchines. First, the new material represents the oldest evidence of the clade thus far, pushing back the origin of Gryposuchinae to the Eocene (41.5–42.5 Ma). Second, this represents the easternmost occurrence of the clade, indicating that gryposuchines roamed the Tethys Sea before its closure. Finally, preservation of the Pakistan crocodylian in rocks deposited in an open marine setting suggests that this individual was capable of navigating marine habitats, consistent with the occurrence of other gavialids in coastal marine settings.

Funding Sources We acknowledge funding resources to the Department of Earth and Environmental Sciences Scott Turner Award 2019 and 2022 for supporting this project.

Technical Session 3: Marine Reptiles (Wednesday, November 2, 2022, 8:00 AM)

ONTOGENY OF THE OLDEST SECONDARILY AQUATIC REPTILE: WHAT MESOSAURS TELL US ABOUT THE EVOLUTION OF DEVELOPMENT IN EARLY AMNIOTES

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Development is among the primary drivers and constraints of morphological diversity, but our understanding of its patterns in deep time is limited by the incompleteness of the fossil record and the absence of genetic material. Yet, exceptional fossils sometimes allow us to fill the gaps. In the framework of my doctoral studies, I studied the ontogeny of mesosaurs, an early Permian group of reptiles that represents the first secondarily aquatic amniotes and one of the most basal clades of parareptiles. Excellent taphonomic conditions and an abundance of specimens have led to the preservation of complete ontogenetic series for the clade. I examined these series to investigate several developmental features in mesosaurs and potential links to their ecology and secondary adaptation to water. Preservation of axial and limb ossification allowed me to reconstruct key development patterns in mesosaurs as well as their ancestral states and evolutionary history within amniotes. My results support the recently proposed synonymy of all three mesosaur species. I highlight limb and skull length reduction associated with tooth elongation during mesosaur ontogeny, likely reflecting a progressive ecological and dietary shift during their growth. My study of vertebral developmental patterns shows a surprising stability in amniotes since their common ancestor despite 300 million years of evolutionary history. Birds, mammals, and squamates each show specific trends in varying from the ancestral condition in amniotes that also remain stable within their lineages. I suggest that this homogeneity of vertebral developmental constraints within these lineages might be linked to their specific modes of regionalization. Limb ossification sequences in mesosaurs exhibit postaxial dominance like modern amniotes, confirming its presence in parareptiles and basal amniotes. My results provide novel insights into the lifestyle of mesosaurs and the evolution of developmental patterns in early amniotes, emphasizing the importance of studying ontogenetic sequences in the fossil record.

Funding Sources This work was supported by the German Research Foundation DFG FR 2457/6-1.

Technical Session 11: Synapsida (Friday, November 4, 2022, 8:00 AM)

NETWORK-BASED BIOSTRATIGRAPHY FOR THE LATE PERMIAN-MID TRIASSIC BEAUFORT GROUP IN SOUTH AFRICA ENHANCES BIOZONE APPLICABILITY AND STRATIGRAPHIC CORRELATION

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The Beaufort Group vertebrate assemblage zones (AZs) of South Africa's Karoo Basin have become a standard for local and global correlations of Permo-Triassic strata. However, temporal, geographical and methodological limitations challenge the reliability of these biostratigraphic units. We analyzed a unique fossil dataset comprising 1408 occurrences of 115 species grouped into 19 stratigraphic bin intervals spanning the *Cistecephalus*, *Daptocephalus*, *Lystrosaurus declivis*, and *Cynognathus* AZs. Using network science tools, we compare frameworks based on historical data (Broom, Rubidge) and modern schemes incorporating recent lithostratigraphic, chronostratigraphic (unconformities), radiometric, and paleontological information (Viglietti, Formation, Member). We also test an additional framework suggesting diachroneity of the *Daptocephalus/Lystrosaurus* AZ boundary (Gastaldo) to determine whether it is an improvement over other frameworks in the study. By modelling fossil occurrence data as bipartite networks, we demonstrate that historical frameworks still identify meaningful AZs and can be useful in corroborating frameworks that identify more unique Karoo Basin AZs. None support the *Cistecephalus* AZ, and it likely comprises two discrete communities. The *Lystrosaurus declivis* AZ is traced across all models, despite many shared species with the underlying *Daptocephalus* AZ. This suggests the extinction event across this interval is not a statistical artifact. An AZ shift with few shared species at the Katberg/Burgersdorp formation boundary may indicate a depositional hiatus. This has important implications for regional correlations, and Mesozoic ecosystem evolution. Analysis of meter-level occurrence data indicates that 20-50 m sampling intervals adequately capture Karoo AZs. Despite its different temporal groupings, the Gastaldo model still identifies the *Lystrosaurus/Daptocephalus* AZ shift, does not significantly improve recent AZ models (Viglietti), and highlights important issues with some AZ studies. Over-interpretation of localized bed-scale lithostratigraphy (sandstone datums), and singleton fossils cannot be used to reject patterns shown by hundreds of fossil specimens, and regional (> 100 km) chronostratigraphic markers of the Karoo foreland basin. Our results unify the use of meter-level placements of singleton fossils to delineate biozone boundaries, and improves Karoo AZ applicability for correlations across southern and eastern Africa, and globally.

Funding Sources The Women's Board, Grainger Bioinformatics Center, Field Museum of Natural History, Chicago, IL.

Technical Session 17: Fish (Saturday, November 5, 2022, 8:00 AM)

REASSESSMENT OF LATE JURASSIC ELASMOBRANCH FISHES

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Elasmobranchs (sharks, rays, skates) represent one of the most successful vertebrate groups, spanning a long geological time and continuously occupying essential roles in the food chain as predators and regulators of other groups. Notwithstanding recent attempts to improve our knowledge of shark and batoids (rays and skates) paleobiodiversity patterns, our understanding of their taxonomy and systematics during long times of their evolutionary history remains inadequate. Although the Late Jurassic–Early Cretaceous interval (164–100 Ma) represents one of the main transitional periods in life history, this interval has received little attention in the case of elasmobranch fishes. Based on the fossil record, both sharks and batoids were already easily recognizable by this time, and representatives for both clades were already present seemingly undergoing a phase of increasing diversification during this period, eventually displacing more plesiomorphic groups like the hybodonts, but also supposed stem group members such as the *Synechodontiformes*.

We present here a comprehensive morphological revision of the *Synechodontiformes* within a systematic framework, a widely distributed fossil group during the Mesozoic era whose phylogenetic relations are dubious and controversial since several decades. Our study is based on a new morphological character matrix produced from the revision of several holomorphic specimens housed in different European collections. This study focuses on several Late Jurassic *Synechodontiformes* (*Synechodus dubrisiensis*, *Sphenodus dubrisiensis*, *Paraorthacodus jurensis*, *Palidiplospinax enniskilleni* and *P. smithwoodwardi*), but also extinct hexanchiforms (*Notidanooides muensteri*), angel sharks (*Pseudorhina acanthoderma*) and extinct batoids (*Spathobatis bugesiacus*, *Belemnobatis sismondaei*, *Asterodermus platypterus*) in order to review the systematic position of supposed members of stem elasmobranchs. Both TNT (Parsimony) and PAUP (Maximum Likelihood) are used and compared to provide a fresh outlook and a complete picture of the phylogenetic relations of these extinct elasmobranchs. The systematic positions of *Sphenodus* and *Palidiplospinax*, especially, are reconsidered based on our results.

Funding Sources This research was funded in part, by the Austrian Science Fund (FWF) [P 33820, P 35357B].

Technical Session 12: Rodents & Quaternary Mammals
(Friday, November 4, 2022, 1:45 PM)

THE BIOGEOGRAPHY AND EXTINCTION TIMING OF ENDEMIC RODENTS ON HISPANIOLA DURING THE HOLOCENE

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Hispaniola is the second-largest island in the Caribbean Archipelago and along with Cuba is considered the cradle of Greater Antillean rodent evolution and diversification. While the fossil record in Hispaniola includes ten extinct species of late Quaternary rodents, only a single species, the Hispaniola hutia (*Plagiodontia aedium*), is still extant on the island. Changes in climate and anthropogenic effects have been suggested as drivers for these extinctions, but there are few radiometric dates associated with these fossils which limits our understanding of the timing of rodent extinctions on Hispaniola relative to shifts in Holocene climate and major events in human settlement and colonization. We report nine new AMS radiocarbon dates for six endemic rodents of Hispaniola that, when coupled with previously reported dates, provide last occurrence records for eight of the ten extinct rodent species from Hispaniola. Results show that Hispaniola rodent extinction occurred in a series of episodes, with more than half (63.6%) surviving into the late Holocene, postdating the initial arrival of Ceramic Age Indigenous groups, with extinction likely only after European colonization. This pattern in Hispaniola is consistent with what recent studies have found on the timing of extinction of other terrestrial vertebrates in the Caribbean Archipelago. Results from analysis of stable isotopes of fossil bone suggest that the extinction of endemic rodents from Hispaniola largely also postdate habitat changes following the onset of drier conditions in the late Holocene, suggesting that while climate may have shaped the geographic distribution of species, it probably played a minimal direct role in their extinctions on Hispaniola.

Funding Sources American Society of Mammologists, Natural History Summer 2021 Travel Award, Florida Museum South Florida Archaeology and Ethnography, and Vertebrate Paleontology

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

NEW HYRACOIDS (MAMMALIA: AFROTHERIA) FROM THE EARLY OLIGOCENE OF TOPERNAWI, TURKANA BASIN, KENYA

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Hyracoidea (hyraxes) are a dominant component of Paleogene African faunas, but underwent a major loss in diversity sometime near the Paleogene-Neogene boundary and remain depauperate today. The scope and evolution of this lost diversity remains difficult to document due to the scarcity of terrestrial vertebrate sites from the Paleogene of Africa. A new site, Topernawi, in the Turkana Basin, Kenya preserves fossils from 29.24–29.7 million years ago, approximately the same age as the youngest hyracoid-rich localities of the Jebel Qatrani Formation in Fayum, Egypt, but geographically closer to younger East African localities with distinctive or hyracoid-poor faunas. Topernawi provides an opportunity to fill the gap between these sites. We use its sample of fossilized hyracoids to understand if previously documented differences in hyracoid communities between Egypt and Kenya are due to biogeographic provincialism, turnover through time, or both.

Among the hundreds of fossils recovered thus far from Topernawi we recognize five species of hyracoid, all of which are undescribed to date. Estimated body masses range from ~6 kg for the smallest-bodied hyracoid species to ~295 kg for the largest-bodied, comparable to body size diversity within Fayum hyracoid faunas with the exception of the largest titanohyracids. Most species are more closely related to extinct taxa from the Fayum than to younger, Miocene taxa based on a Bayesian tip-dated phylogenetic analysis. The overall similarity between the hyracoids of Topernawi and Fayum localities supports the hypothesis that the distinctly different, late Oligocene–early Miocene hyracoid faunas of East Africa are the result of turnover rather than biogeographic provincialism.

Funding Sources NSF BCS-2124790 (PP) 2124792 (NSV, IN), TBI Research Fund (PP), Leakey Foundation (IN)

Technical Session 6: Dinosaur Macroecology & Macroevolution (Thursday, November 3, 2022, 1:45 PM)

ENDOCRANIAL ONTOGENY IN *GORGOSAURUS LIBRATUS* (TYRANNOSAUROIDEA: TYRANNOSAURIDAE) REVEALS NEW INFORMATION ON BRAIN EVOLUTION IN THEROPODS

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Endocranial morphology has been the subject of several studies in theropods. Among these, tyrannosauroids have arguably received the most attention. Nevertheless, the ontogenetic changes that occurred within the tyrannosauroid endocranium remain largely unknown due to the rarity of adequately preserved braincases of immature individuals (i.e., less than 50% of largest adult skull length). The recent

discovery of two exceptionally preserved juvenile *Gorgosaurus libratus* skulls, both preserving complete braincases, offers an opportunity to examine these ontogenetic trends.

X-ray computed tomographic (CT) scans reveal juvenile and adult *Gorgosaurus* specimens to share a largely similar endocranial morphology. All possess an extensive system of paratympanic sinuses that pervade most of the braincase bones, a well-developed vestibulocochlear system with a long and straight lagena, and a moderately elongate endocast. Juvenile *Gorgosaurus* individuals, however, differ from more mature individuals in having a less inflated tympanic sinus system and a relatively large endosseous labyrinth, but perhaps the most significant difference occurs in the brain-to-endocast correspondence. The endocast of mature tyrannosauroids exhibit poor distinction of neural structures of the brain, such as the cerebrum and optic lobes. In contrast, juvenile *Gorgosaurus* show better defined neural structures, exhibiting small but well-defined cerebral hemispheres and large, laterally positioned optic lobes. These observations suggest a decrease in the brain-to-endocast correspondence through ontogeny likely due to growth of the brain cavity exceeding that of the brain.

The endocast morphology of juvenile *Gorgosaurus* also provides new information on brain evolution in theropods. The small size of the cerebrum indicates that tyrannosauroids diverged from other coelurosaurs prior to evolution of forebrain expansion. However, the occurrence of laterally positioned optic lobes in *Gorgosaurus* suggests that forebrain expansion was not the primary driver in the displacement of the optic lobes from a more medial position, between the cerebrum and cerebellum, to their more lateral position in coelurosaurs. Given our observations in juvenile *Gorgosaurus*, we propose that examination of the endocrania of immature individuals, with their smaller venous sinuses and better-defined neural structures, will greatly improve our understanding of brain morphology in other, more basal theropods.

Funding Sources University of Calgary, Alberta Heritage Preservation Partnership Program, Dinosaur Research Institute Royal Tyrrell Museum Cooperating Society, NSERC

Technical Session 1: Dinosaurs (Wednesday, November 2, 2022, 8:00 AM)

NEW DATA ON LATE JURASSIC GONDWANAN DINOSAUR FAUNAS FROM THE OXFORDIAN-KIMMERIDGIAN CAÑADÓN CALCÁREO FORMATION OF CHUBUT, ARGENTINA

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Our knowledge of Late Jurassic dinosaur faunas is still largely based on the northern hemisphere, with the only diverse Gondwanan dinosaur fauna being that of the Tendaguru Formation of Tanzania. Otherwise, only the Oxfordian-Kimmeridgian Cañadón Calcáreo Formation of Chubut, Argentina, has yielded more than a single named dinosaur taxon from the Late Jurassic of Gondwana so far, including the basal macronarian *Tehuelchesaurus*, the dicraeosaurid *Brachytrachelopan*, and the basal tetanuran theropod *Pandoravenator*, in addition to undiagnostic remains of a diplodocid and a basal titanosauriform. Recent fieldwork in this unit has led to the discovery of additional dinosaur remains. The presence of stegosaurs is demonstrated by an isolated humerus and footprints. New theropod material include the first abelisaurid remains from the Late Jurassic of South America and a new specimen of *Pandoravenator*, which shows that this taxon is an early branching coelurosaur, representing the first record of this clade from the Jurassic of Gondwana. A further, unusual theropod is represented by at least three partial articulated skeletons, together representing most of its osteology. The material represents a new taxon of medium-sized theropod with an unusually broad and short-snouted skull, elaphrosaurine-like cervical vertebrae, and robust forelimbs with a tetanuran-like three-fingered manus. The opisthopubic pelvis with a low and simple ilium resembles that of the enigmatic *Chilesaurus*, but the pes is more typical theropodan in having the first metatarsal displaced distally from the tarsus. Two new sauropod taxa are represented by a partial articulated vertebral column and an associated postcranial skeleton, respectively. One is an early branching macronarian that resembles *Tehuelchesaurus* in having transversely compressed dorsal neural spines, but differs from this taxon in several characters, such as the number of dorsal vertebrae and the lateral vertebral lamination. The second specimen represents a basal titanosauriform that combines *Tendaguria*-like anterior dorsal vertebrae with *Giraffatitan*-like posterior dorsals and anterior caudals that resemble those of the proposed mamenchisaurid *Wamweracaudia*. These new finds thus give insights into Gondwanan Late Jurassic dinosaur diversity and help interpreting some previously problematic Gondwanan taxa.

Funding Sources Deutsche Forschungsgemeinschaft; Agencia Nacional de Promoción de la Investigación Científica y Técnica; Fundación Egidio Feruglio

Symposium: A Late Miocene Shangri-la (Wednesday, November 2, 2022, 1:45 PM)

MUST WALK AND “CHEW”: THE FALSE THUMB OF THE GIANT PANDA FROM SHUITANGBA SUGGESTS CONFLICTING DEMANDS FOR LOCOMOTION AND FEEDING IN THE EARLIEST PANDAS

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Of the many peculiarities that enable the giant panda (*Ailuropoda melanoleuca*), a member of the order Carnivora, to adapt to life as a dedicated bamboo feeder, its extra “thumb” is arguably the most celebrated yet enigmatic. In addition to the normal five digits in the hands of most mammals, the giant panda has a greatly enlarged wrist bone, the radial sesamoid, that acts as a sixth digit, an opposable “thumb” for manipulating bamboo. The manner in which this radial sesamoid has evolved is not clear due to a near total absence of evidence from the fossil record. The panda’s false thumb remains a puzzle because it is a rather inconspicuous structure barely protruding out of the palm despite its seemingly obvious functional advantage for manipulating bamboo. Is this structure still rudimentary because it is relatively recently evolved? Or are there other factors that have prevented it from becoming a full digit?

Discovery of a fossil false thumb from an ancestral giant panda, *Ailurarctos* cf. *A. lufengensis* Qiu and Qi, 1989, in the late Miocene site of Shuitangba (6-7 Ma) in Yunnan Province, south China, permits a first look at an early condition of this extra digit. Unexpectedly, the early panda’s false thumb is longer than those of its living relatives, and has a relatively straight end in contrast to those in living pandas with a hook at the distal end. We propose that the panda’s “thumb” stopped lengthening after initial enlargement because the radial sesamoid must serve the dual functions of, 1) manipulating bamboo on its internal, hooked tip, and 2) bearing weight on its external surface in plantigrade posture. Evolution of the false thumb is thus a trade-off between the need for an extra digit for food procurement against the burden of bearing the body weight on this digit.

The above hypothesis implies that giant pandas had ample time (about 6 million years) to further lengthen their “thumbs” but failed to do so because of the countervailing pressure for shortening the digit. This evolutionary compromise resulted in a “thumb” that is long enough for grasping bamboo but that does not protrude to the extent that it impedes locomotion. Knowledge about the evolution of the false thumb is important because the only likely function of a lengthened radial sesamoid is grasping bamboo for feeding. By extension, the Shuitangba panda offers the earliest evidence of an obligatory bamboo feeder.

ELLIPTIC FOURIER ANALYSIS AS A TOOL FOR TAXONOMIC IDENTIFICATION OF ISOLATED THEROPOD PEDAL PHALANGES

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Studies of terrestrial to coastal vertebrate bonebeds from the Cretaceous of Western North America have greatly increased our understanding of paleocommunity structure in the later Mesozoic. Although many isolated elements in these deposits can be readily identified to family-, genus-, or species-level, others are difficult to identify below a very coarse level. Isolated theropod pedal phalanges are an example of the latter. These elements can generally be assigned a skeletal position with reasonable accuracy, but often cannot be identified to taxon beyond 'Theropoda indet.'. Exceptions do exist, where discrete characters allow for more narrow identification (particularly in the case of unguals), but taxonomic resolution has been limited due to a lack of data regarding the variation that exists in these bones individually, ontogenetically, interspecifically, and as a result of functional constraints related to body size.

In an attempt to alleviate this issue, we quantified the morphospace occupation of pedal phalanges from a range of Late Cretaceous theropods with relatively complete pes to identify elements and features most strongly associated with particular taxa. We used a morphometric approach called elliptic Fourier analysis, which fits a series of harmonic functions to two-dimensional coordinate data derived from digitized object outlines. The coefficients of the resulting harmonic functions allow the shape to be accurately described while also limiting the number of variables used, thereby preventing excessive data dimensionality.

Our dataset, consisting of tyrannosaurids, caenagnathids, ornithomimids, and troodontids, demonstrates the effectiveness of the approach. For example, caenagnathids are distinguishable from other theropods based on several features, including the relative lengths of phalanges III-1 and III-3. Ornithomimids and tyrannosaurs are also distinguishable, particularly when comparing ornithomimids to adult/large-bodied tyrannosaurs. The difference is more subtle between ornithomimids and juvenile tyrannosaurids, where their proximal phalanges overlap in morphospace but distal phalanges remain distinct. As this dataset grows, its utility for the direct inclusion and identification of isolated materials will continue to improve, as will the insights it can provide concerning anatomical variability in these commonly preserved but often taxonomically-evasive elements.

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

EVOLUTIONARY MODE IN DERIVED TYRANNOSAURINAE

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Cladistic phylogenetic methods and 2D Geometric Morphometrics were conducted on various derived tyrannosaurines (Coelurosauria: Tyrannosauridae) in order to reevaluate the phylogeny and patterns of evolutionary change within this clade. Evidence from both of these is supportive of anagenesis between *Daspletosaurus* and more derived tyrannosaurines (e.g., *Tyrannosaurus*). A newly discovered stratigraphic and morphological intermediate between *D. torosus* and *D. horneri* additionally supports anagenesis between these taxa, and between the latter and *Tyrannosaurus*. These findings underscore the explanatory power of anagenesis in the generation of morphological novelty among dinosaurs of the Late Cretaceous Western Interior.

Virtual Posters

GIGANTIC SPERM WHALE TOOTH (CF. *LIVYATAN*) FROM THE MIOCENE OF SOUTHERN CALIFORNIA

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A fossil tooth from the middle-upper Miocene Monterey Formation in the Orange County Cooper Center paleontology collection suggests that a gargantuan sperm whale once inhabited the Miocene seas of Southern California. Though difficult to diagnose to genus level based upon a single, incomplete tooth, comparisons with known Miocene physteroid whales provides key insight into the affinities of this fossil. Even though the tip is broken, the entire tooth measures over 250 mm long, and 86 mm in diameter. It has enamel only on the tip of the broken crown, and no enamel coating over the rest of the tooth. The rest of the tooth consists of cementum layers over a core of ossified dentin. It is just slightly smaller than the largest teeth of the largest member of

Physeteridae, the South American Miocene *Livyatan*, a genus that has never been found outside of the Southern Hemisphere. It is also just slightly smaller than similar gigantic teeth reported from South Africa and Australia. Other Miocene members of the family that were relevant for comparisons included *Albicetus*, *Hoplocetus*, *Scaldicetus*, and *Zygophyseter*, but none have teeth as large as this one. It is bigger than the known specimens of other Miocene physteroid whales, including the other whale from the Monterey Formation, *Albicetus oxymycterus*. This fossil suggests that giant physteroid whales closely related to *Livyatan* lived in North America. It represents a substantial geographic range extension for giant physteroid whales, previously known only from the Miocene of the Southern Hemisphere.

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

TRENDS TOWARDS DECREASING MANDIBULAR COMPLEXITY THROUGH TIME IN AMPHIBIANS AND STEM TETRAPODS

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Tetrapods (limbed vertebrates) have undergone considerable evolutionary changes during and since their initial water-to-land transition around 390Ma. Following this major ecological shift, there was a surge in morphological diversity due to expansion into unexplored terrestrial niches. This included acquisition of a breadth of morphological adaptations for new diets and foraging strategies. Whereas trends across this evolutionary radiation in cranial anatomy and locomotor structure/function are well-understood, less attention has been given to the evolution of the mandible. Mandibular and dental morphology are thought to be important because they reflect both adaptations to different diets and also developmental and phylogenetic constraints. Here, we reconstruct morphological evolution of the tetrapod mandible to identify trends in number of elements and shifts in disparity through time, potentially related to large-scale events (e.g. mass extinctions). We further test for evidence of Williston's law which predicts that there will be a trend towards decreased jaw elements observed across tetrapods. We scored 570 species of early tetrapods, temnospondyls, lepospondyls, and lissamphibians for 38 traits, including tooth count and mandible complexity (number of elements). We performed disparity through time and principal coordinates (PCoA) analyses and tested macroevolutionary tempo and mode in these traits. PCoA indicated that jaw morphology is largely influenced by phylogeny along PCO1, which represents the majority of variation in the dataset (four times the next highest axis). Only PCO1 explains more variation than expected under a broken stick model, after applying a Lingoes correction for negative eigenvalues. Jaw disparity generally increases through time, with the most rapid increase observed since the end of the

Eocene. Our results demonstrate that the lower jaw has undergone substantial morphological and structural change across tetrapod evolution, but different aspects of jaw morphology show distinct evolutionary patterns. Overall, these results support Williston's law with a general decrease in mandibular complexity observed in early tetrapod and amphibian clades.

Funding Sources London NERC Doctoral Training Partnership Programme

Technical Session 16: Hoofed Mammals (Saturday, November 5, 2022, 8:00 AM)

A SMALL ARCHAIC UNGULATE SKULL FROM THE EARLY PALEOCENE DENVER FORMATION OF COLORADO (CORRAL BLUFFS, EL PASO COUNTY)

Weaver, Lucas N.¹, Chester, Stephen G.², Crowell, Jordan W.³, Lyson, Tyler R.⁴

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The recovery and rise of mammals in the early aftermath of the Cretaceous–Paleogene (K–Pg) mass extinction is best documented by the western North American fossil record, yet that record consists almost entirely of isolated teeth and jaw fragments. Recently, however, exceptionally preserved mammal skulls have been discovered in phosphatic concretions at Corral Bluffs—earliest Paleocene exposures of the Denver Formation in an area just east of Colorado Springs, CO—which may help clarify the obscured phylogenetic relationships and ecologies of many early Paleocene mammals. Here we report the discovery of a well-preserved partial skull (DMNH EPV.136181) of a small-bodied archaic ungulate from ca. 600 ka after the K–Pg boundary (Puercan 2 North American land mammal 'age') at Corral Bluffs. Although the skull is mediolaterally compressed and much of the rostrum is missing, it includes partial maxillae and dentaries with posterior premolars and molars in occlusion on both sides and bones of the neurocranium and basicranium, including partial petrosals with the left side preserving aspects of the promontorium and tegmen tympani. Digital preparation of micro-CT scans has revealed dental features of DMNH EPV.136181 that resemble those of the conacodontine periprychid, *Oxyacodon*, such as (1) prominent hypocones on upper molars that project lingually beyond the protocones, (2) somewhat inflated P/p4 that are slightly smaller than M/m1, and (3) small paraconids on m1–3 situated on the midline. DMNH EPV.136181 also exhibits dental features that more closely resemble more basal archaic ungulates (e.g., *Mimatuta*, *Maiorana*), such as (1) a taller trigonid, (2) trigonid cusps that are not as closely appressed, and (3) a larger talonid basin. This combination of dental features suggests that DMNH

EPV.136181 is a phylogenetically basal periptychid, and it therefore may help clarify aspects of early archaic ungulate systematics, such as the phylogenetic relationship between more basal taxa like *Mimatuta* and *Maiorana* and the Periptychidae. Further, given that crania of periptychids are primarily known only from derived and mostly large taxa, differences documented in the cranium of DMNH EPV.136181, such as a petrosal with a prominent epitympanic wing and an anterodorsal process of its jugal that does not expand to occupy the lateral side of the anterior zygomatic root, may shed light on early cranial evolution within the Periptychidae.

Technical Session 13: Early Archosaurs & Pterosaurs (Friday, November 4, 2022, 1:45 PM)

FROM SEA TO SKY: WATER LAUNCH AND SOARING PERFORMANCE IN THE LATE CRETACEOUS PTEROSAUR, *NYCTOSAURUS*

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Nyctosaurid pterosaurs have previously been interpreted as rapid-soaring specialized pelagic animals. However, there have been limited efforts to quantitatively validate these interpretations. Using a composite reconstruction of *Nyctosaurus*, we applied a numerical modeling approach to test existing interpretations of the in-flight behavior of this unusual pterosaur taxon, as well as to investigate its potential launch performance from both land and water. We relate our flight performance analysis to previously reconstructed conditions around the ancient Western Interior Seaway (WIS) to elucidate details of the likely ecology of *Nyctosaurus*. To account for uncertainty in wing shape and total mass in our *Nyctosaurus* reconstruction, we built five models with varying wing dimensions and body mass. Published span-to-mass relationships for pterodactyls were used to estimate a baseline mass. Our numerical models take into account known relationships between wing shape, body mass, fluid density, lift generation efficiency, and flapping kinematics. We incorporated recently published water launch models for a pterosaur “quadrupedal water launch”. Our median model (for both body mass and aspect ratio) estimated steady state stall speeds of 7.4 m/s and steady cruising speeds near 11.00 m/s. Heavier mass versions would fly even faster. At a launch angle of 55 degrees from horizontal launch times ranged from a minimum of 0.04 s to 0.08s with vertical velocities of a minimum 4.09 to 7.27 m/s. Thanks to the highest aspect ratio estimated for any pterosaur (at least 18), *Nyctosaurus* was exceptionally efficient at extracting energy while soaring. Our estimates of minimum sink ranged from 0.15 to 0.22 m/s - low enough to rise even in weak ocean thermals. These results suggest a relatively fast soaring animal, which could indicate gust-soaring specialization. However, performance in large diameter thermals was also excellent. Geologic evidence from turbidites in the Niobrara formations suggest that the WIS

experienced regular storms. The warm conditions and relatively shallow depth would have been ideal for marine thermal production. These habitat data, combined with our results, suggest a paleoecology for *Nyctosaurus* that included both gust flying and thermal flying, switching based on conditions. These results help us bring together a more detailed image of the flight mechanisms and life history of *Nyctosaurus* in the late Cretaceous.

Symposium: International Community Connections
(Wednesday, November 2, 2022, 1:45 PM)

MULTI-LANGUAGE TRANSLATION OF *SHE FOUND FOSSILS: A SELF-PUBLISHED CHILDREN'S BOOK ON WOMEN IN PALEONTOLOGY*

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Until 2017, there was a paucity of books on women paleontologists, which caused a lack of these role models (especially for children), but also perpetuated the mistaken notion that paleontology continues to be pursued mostly by men. In 2015, we proposed the book *She Found Fossils* to remedy this need. The idea of a biographical collections of women was unheard of at the time, so publisher support was lacking, therefore we pursued public funding and ran a Kickstarter campaign to accomplish our goals. The original aim was to publish the book in English and Spanish, but the campaign raised 350% of our requested funds by backers in 11 countries, so we committed to an additional translation into Mandarin.

Each translation required a new set of images in the corresponding language, as well as translation/editing of the text, and reformatting of the text pages in illustrator. MELG translated the book into Spanish, and hired an editor to make the final adjustments. For Mandarin, we hired a translator to convert the entire book, but then experienced difficulties incorporating those changes. To aid us, we brought in JL to make and insert the final changes into the document. Lastly, finding a print-on-demand service that made physical copies of the book in Mandarin was a challenge. These snags delayed the publication of the Mandarin edition by 4 years after the publication of the English and Spanish editions. All 3 editions are now available through Amazon. To date, we have sold over 800 copies across the 3 languages.

Additional challenges stemmed from self-publication beyond the translation adjustments. Museum gift shops and public libraries are set up to order books from publishers through pre-set accounts, but not through credit card ordering systems like Amazon. Unless those venues reach out to us directly, it remains difficult for our book to enter these distributors. We

have partially circumvented this issue by donating copies of the book ourselves to local schools and public libraries, and sending copies at-cost to museum gift shops. We intend to work with the non-profit First Book to distribute 500 copies to underserved communities; however, we need to raise the funds to purchase those copies ourselves, as they have the same purchasing restriction as gift shops and libraries. Our backers have indicated their desire for a sequel, but without support from a publisher, we do not believe this would reach the underserved populations it would benefit the most.

Funding Sources This project was funded by public donations through Kickstarter.

Technical Session 13: Early Archosaurs & Pterosaurs (Friday, November 4, 2022, 1:45 PM)

SYMPATRIC SPECIES OF *ISALORHYNCHUS* (RHYNCHOSAURIA, ARCHOSAUFOMORPHA) AND THE FIRST OCCURRENCE OF *HYPERODAPEDON* FROM THE TRIASSIC OF MADAGASCAR

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Rhynchosaurs diversified significantly during the Middle to Late Triassic, and occur widely in deposits across Gondwana. Since it was named on the basis of limited material in 1983, *Isalorhynchus genovefae* represented the sole Malagasy record of the group. Subsequent collecting in channel and floodplain deposits in the island's southwest has yielded abundant amniote remains, including of four traversodontid eucynodonts, a kannemeyeriiform dicynodont, plus basal members of Archosauromorpha and Ornithodira. We report here two previously unknown rhynchosaurs from the "basal Isalo II," recovered by joint expeditions of the Field Museum of Natural History/University of California/Université d'Antananarivo between 1996-2003. One of these, a new species of *Isalorhynchus*, is distinguished by a plesiomorphic single row of large maxillary teeth lateral to the longitudinal groove, which bisects the occlusal surface, that co-occurs with advanced features such as anteromedially and posteromedially directed flanges on those same maxillary teeth, three full rows of teeth on the medial occlusal surface of the maxilla, and two full rows of teeth on the dentary, separated from each other by additional teeth on the element's posterolingual surface. Shared common apomorphies of *Isalorhynchus* n. sp. and *I. genovefae*, plus provenance from the same locality, suggests their divergence from a common ancestor.

We also report the first occurrence of *Hyperodapedon* from Madagascar, a geographically widespread taxon diagnosed by ≥ 3 tooth rows on the lateral occlusal surface of the maxilla and a secondary posteromedial tooth row on the dentary. The basal Isalo II has been correlated with the Ladinian-Carnian Santa Maria Supersequence (Santacruzodon Assemblage-Zone) based on the shared occurrence of the traversodontid eucynodont *Menadon besairie* and other related massetognathines and chiniquodontid cynodonts. *Hyperodapedon* occurs abundantly only in younger strata of the *Hyperodapedon* Assemblage Zone in southern Brazil and other Carnian to earliest Norian deposits. The presence of *Hyperodapedon* in the basal Isalo II therefore suggests a geographic and likely temporal range extension for *Hyperodapedon*.

Funding Sources National Geographic Society Grant Numbers: 6271-98, 6545-99, 6844-00, and 7052-01 to JJF and colleagues.

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

A LATEST OLIGOCENE OCCURRENCE OF FEATHER-TAIL POSSUMS (ACROBATIDAE: MARSUPIALIA) FROM THE WIPAJIRI FORMATION, SOUTH AUSTRALIA

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The family Acrobatidae (feather tailed possums) was previously considered to have a minimal fossil record restricted to the last five hundred thousand years. This family includes *Acrobates pygmaeus*, the feather-tail glider from Australia, and *Distoechurus pennatus*, the feather-tail possum from New Guinea. The holotype specimen, UCMP-131924, was discovered in the latest Oligocene Wipajiri Formation in South Australia, which formed about 24 Ma. Here, a new species of the family Acrobatidae is described based on the phylogenetic analysis of a lower left jaw fragment.

The jaw fragment retains the first and second molars fully intact, a partial third premolar, and the alveoli for the first two premolars and the back two molars. The lower molars of acrobatids are unique in that the cristid obliqua runs across the talonid basin towards the lingual side of the tooth. The presence of this feature, among others, led to the initial hypothesis that UCMP-131924 was a member of Acrobatidae. However, the Wipajiri specimen differs from other acrobatids due to the presence of an m4 as evident from a partial alveolus at the posterior end of the jaw fragment. A phylogenetic analysis was conducted to determine UCMP-131924's relationship with known possum families, and to test the initial hypothesis that it was a member of Acrobatidae. The new specimen was compared with 17 other species from Australian

possum families, including Acrobatidae, Burramyidae, Petauridae, Phallangeridae, and Pseudocheiridae. A total of 44 characteristics of the teeth and jaws were used to compare the different possum species. A bootstrap/jackknife analysis on randomly generated phylogenetic trees created with PAUP support the hypothesis that the late Oligocene acrobatid is the sister taxon to two extant acrobatids, *Acrobates* and *Distoechurus*.

This discovery builds on the natural history of Acrobatidae. UCMP-131924 extends the temporal range of Acrobatidae from the past 0.5 Ma back to the past 24 Ma. In addition, the presence of this arboreal acrobatid supports the hypothesis that the region had a wetter riparian environment during the end of the Oligocene, in stark contrast to the dry desert that it is today. Lastly, this study adds to the diversity of the Kutjamarpu local fauna which comes from the Wipajiri Formation.

Technical Session 8: Evolutionary Developmental Biology
(Thursday, November 3, 2022, 1:45 PM)

MODELLING HOW SUTURE MORPHOLOGY, COMPLEXITY, AND DEVELOPMENT DRIVES MAMMALIAN CRANIAL EVOLUTION

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Sutures provide active growth centres that facilitate cranial bone growth and support skull functioning but have received comparatively little attention in morphometric analyses compared to the well-studied cranium. The development of sutures has been hypothesised to be central in shaping the diverse cranial morphologies observed across Mammalia. Here, we used geometric morphometric techniques to analyse patterns of morphological development for both the mammalian skull and its cranial sutures and quantify the interaction between suture and skull development. Skull and suture morphology was assessed in a comparative ontogenetic framework, using microCT scans of 22 mammalian species spanning the phylogenetic breadth of Mammalia, and ranging from fetal to adult stages. A conserved morphological region was observed for fetal specimens and a cone-shaped pattern of cranial morphological development observed across ontogeny that was reflective of the upper half of the developmental hourglass model. Marsupials displayed differences in the degree and pattern of suture fusion than placentals (marsupial fusion: 71.36%; placental fusion: 76.63%), analysed using 31 sutures; cranial base sutures remained open for longer in marsupial species. Suture complexity was found to be greater for the sutures adjacent to the underlying brain (coronal and sagittal sutures), suggesting a relationship between postnatal brain growth and suture morphological complexity. Ancestral state reconstructions of skull morphological development, timing and rate of suture fusion, and suture complexity identified clear differences between marsupials and placentals,

specifically localising these differences as paedomorphic shifts on the marsupial lineage. Contrary to previous hypotheses, we propose here the novel hypothesis that placental mammal cranial and suture ontogeny better reflects the ancestral therian mammal, while the marsupial cranial and suture ontogenetic trajectories reflect the more derived state of mammal development. Two-block partial least squares analyses identified significant covariation between each suture variable (shape, fusion, and complexity) and skull morphology through ontogeny ($p < 0.05$), indicative of an integrated pattern of morphological development between the skull and cranial sutures. As a result, variation in the development of suture morphology appears to be central to shaping the phenotypic diversity of the mammalian skull.

Funding Sources BBSRC funded PhD for Heather White, Leverhulme funded postdoc for Heather White and Anjali Goswami

Technical Session - New Methods (Thursday, November 3, 2022, 10:15 AM)

A NEW TOOL FOR DESCRIBING FOSSIL BONE MICROSTRUCTURE: LIQUID CRYSTAL CROSS-POLARIZED LIGHT MICROSCOPY AND THE IDENTIFICATION OF MUSCLE ATTACHMENTS AND OTHER STRUCTURES

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Linear cross-polarized light microscopy has long been a staple in paleohistological studies that aim to describe the nature of collagen fibre arrangement in fossil bone. While more commonly used in the description of periodontal ligaments and their role in dental arrangement and replacement, polariscopy can also be used to identify other disruptions to bone structure caused by growth and pathology. Two key limitations to linear polariscopy are that it can only visualize the birefringence of a histological sample's tissues at a single angle at a time, therefore requiring the physical manipulation of the sample to capture the nature of all the specimen's inherent tissue. In addition, linear polariscopy is a purely qualitative analysis. To overcome these limitations, liquid crystal polarized light microscopy is applied to the fossil record for the first time. Thin-sections of a *Centrosaurus* ulna and tibia as well as three *Edmontosaurus* humeri are sampled. Within each of these samples, the orientation of collagen fibres (or fossilized remnants thereof) is observable simultaneously, more readily elucidating disruptions to bone microstructure that may be associated with muscle attachment or pathology. The incorporation of silica into fossil material during permineralization increases birefringence beyond the intended parameters of the liquid crystal polariscopy's associated software. Despite this, we can easily identify familiar structures including Haversian remodelling, lines of arrested growth, and Sharpey's fibres. While these structures

are identifiable using linear polariscopy, the liquid crystal filter affords ability to directly measure and quantify changes in fibre density and orientation. Using birefringence as a fibre-density proxy, we can infer areas of increased density as muscle attachment sites despite an absence of any macroscopically visible muscle scarring at the bone surface. Fibre density is quantified by plotting brightness (nm) against a standardized transect of the bone sample. Further investigation into the use of this imaging modality for fossil material is certainly warranted as more accurate identification of the locations and nature of soft tissue attachments has major ramifications for biomechanical studies.

Funding Sources This research is funded by a 2021 Australian Government RTP Scholarship Stipend, held at the University of New England – Australia by S. Amber Whitebone.

Regular Poster Session 1 (Wednesday, November 2, 2022, 4:30 - 6:30 PM)

AN UNRECOGNIZED BOUNTY: THE FOURTH DICRAEOSAURID SAUROPOD FROM THE MORRISON FORMATION (LATE JURASSIC) OF NORTH AMERICA

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Carnegie Museum (CM) specimen 26552 is a braincase and partial skull roof from the Late Jurassic Carnegie Quarry at Dinosaur National Monument. This specimen rose to prominence in the late 1970s as a key part of the “recapitation” of *Apatosaurus* by McIntosh and Berman and subsequently formed the basis for the first modern description of the braincase of *Diplodocus* by those same authors. The relatively simple anatomical and taxonomic knowledge of sauropods at the time, however, coupled with the anatomical similarity between the crania of flagellicaudatans in general, meant that the majority of characters used to delimit *Diplodocus* were proportional rather than discrete. The recent uptick in anatomical and taxonomic information regarding the group, however, suggested that a re-evaluation of the material would prove informative.

We find that CM 26552 is distinct from both *Diplodocus* and *Apatosaurus*, and is most likely affiliated with Dicraeosauridae, based upon seven synapomorphies: 1) the presence of postparietal and frontoparietal fenestrae, 2) the exclusion of the basioccipital from the dorsal margin of the occipital condyle by the exoccipitals, 3) the presence of a distinct prong on the squamosal, 4) contribution of the frontal to the margin of the supratemporal fenestra, 5) an expanded crista prootica, 6) free dorsal margin of the antotic process, and 7) the flat distal margin of the paroccipital process. CM

26552 can further be distinguished from *Suuwassea emeliae* based upon: 1) the presence of a single foramen for passage of the abducens (VI) nerve, 2) a narrow, midline ventral expansion of the foramen for the optic nerve and 3) greater size at maturity; from *Kaatedocus* based upon: 1) the presence of a frontoparietal foramen and 2) the contribution of the frontal to the supratemporal fenestra in CM 26552; and from *Smitanosaurus* based upon: 1) the presence of a broad supraoccipital crest and 2) the contribution of the frontal to the supratemporal fenestra in CM 26552. CM 26552 can be further distinguished from all other dicraeosaurids by a single autapomorphy: the presence of a “tooth” in the parietal/opisthotic suture. Considering CM 26552 as a potential new dicraeosaurid species enhances knowledge of the diversity of this family in the Morrison formation and North America, expanding the historically underestimated sauropod diversity of the unit, and giving additional support to the idea of North America as the center of origin of Dicraeosauridae.

Technical Session 5: Amphibians & Early Reptiles (Thursday, November 3, 2022, 8:00 AM)

LIFE HISTORY FEATURES OF THE GONDWANAN EARLY TETRAPOD *OSSINODUS* REVEALED FROM OSTEO- AND ODONTOHISTOLOGICAL SYNCHROTRON DATA

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Early tetrapod fossils document one of the most momentous transitions in vertebrate evolution—the conquest of the terrestrial landscape. Despite the importance of this event in vertebrate evolution, the fossil record of early tetrapods is remarkably sparse and typically only described from Laurasia. As a result, the extent to which previously described life histories of Laurasian taxa may broadly apply to Gondwanan taxa remains uncertain. Here, we present a comprehensive survey of the histology of *Ossinodus pueri*, the only Gondwanan early tetrapod known from substantial skeletal remains. *Ossinodus* is an Early Carboniferous (Mississippian) tetrapod known from the Ducabrook Formation of Queensland, Australia. Using synchrotron X-ray tomography, we non-destructively examined the histology of appendicular and tooth-bearing cranial elements to develop insight into growth rates, life history trends, and anatomical traits of this pivotal taxon.

Our sample of *Ossinodus* included an ontogenetic series of femora between ~2-7cm in length. The smallest individual has the thickest cortex at the mid-diaphysis (~75% of the cross-

sectional area), becoming increasingly narrow in the largest individuals (>35% of the cross-sectional area). The smallest femur is highly vascularized with organized longitudinal canals that anastomose frequently. Secondary remodeling and erosion of the cortex towards the medullary cavity is evident. In comparison, the larger femora have more spongy bone. An *Ossinodus* maxilla reveals largely plesiomorphic tetrapod features, including ankylosed teeth that fused to jaw bone, tooth bases with plicidentine infolding, and an alternating replacement pattern.

The *Ossinodus* specimens studied have a combination of plesiomorphic and derived features. The histology of the dentition suggests the retention of ancestral characteristics, whilst the fast early ontogenetic bone deposition (elevated growth rate), suggests a more derived trait. Interestingly, the ontogenetic pattern of bone growth in *Ossinodus* is similar to that recently described in *Whatcheeria*, a Mississippian-aged tetrapod from Laurasia. We propose that a rapid juvenile growth phase, followed by reduced deposition rates and erosion of cortices, reflects a life history strategy that was common at the origins of Tetrapoda and may have facilitated the tetrapod invasion onto land.

Funding Sources ANSTO Australian Synchrotron beamline access grant M17466

Technical Session 2: Paleoecology (Wednesday, November 2, 2022, 8:00 AM)

CHANGING CLIMATE PREFERENCES AND FUNCTIONAL STASIS IN MAMMALIAN COMMUNITIES ACROSS THE PALEOCENE-EOCENE THERMAL MAXIMUM OF THE BIGHORN BASIN, WYOMING

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The Paleocene-Eocene Thermal Maximum (PETM) was a major rapid global warming event marking the transition from the Paleocene to the Eocene (~56 Ma), with mean annual temperatures rising by 5° to 8°C following an abrupt carbon isotope excursion lasting 120 thousand years or less. The PETM saw a significant shift in the composition of North American floral communities as well as expansion of perissodactyl, artiodactyl, and primate distributions into North America from Eurasia, which correlated with significant body size change. However, a previous study found little to no change in the phylogenetic and functional components of North American mammal diversity throughout the PETM. We assembled a database of 121 fossil mammal species from the Bighorn Basin, Wyoming, which included body sizes and expanded on the previous work to include inferred diets and

limb postures alongside a database of 40 palynofloral localities as proxies for environment. This database spans 3 primary time bins based on North American Land Mammal Ages (NALMAs), accounting for the periods immediately preceding, during, and immediately succeeding the PETM isotope excursion. For each mammal species, we determined their environmental preferences based on the microfloral assemblages with which they most co-occurred and compared the Euclidean distances in climate preference between pairs of taxa them to each other to determine the breadth of that preference for each studied time bin. For each NALMA, we then calculated mean difference in traits and environmental preference. We found little to no change in trait dispersion across the PETM, aligning with previous work. We found that species occurring during and after the PETM showed higher dispersion in environmental preference, suggesting that mammal species more finely partitioned the available environmental space or had broader climatic niches than previously anticipated. These results indicate the persistence of a stable mammalian functional community structure despite considerable taxonomic turnover as well as a decoupling of Eltonian (morphological) and Grinnellian (environmental) niche occupation.

Funding Sources Canadian Natural Sciences and Engineering Research Council (NSERC)

Technical Session 10: Soft Tissues & Taphonomy (Friday, November 4, 2022, 8:00 AM)

TRACING THE FIDELITY OF MOLECULAR BIOSIGNATURES THROUGH GEOLOGICAL TIME TO REVEAL MAJOR STEPS IN THE EVOLUTION OF VERTEBRATES

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Recent conceptual progress on the chemical transformation of biomolecules during fossilization has drawn attention to preserved carbonaceous remains as an underexplored resource of molecular biological information. The molecular makeup of fossil vertebrate tissues has been demonstrated to preserve original signals encoding biomineralization, tissue identity, metabolic capacity, and organismal relationships, each corresponding to related chemical signals in modern tissue analogues. While such molecular information has the potential to aid in resolving major questions in the evolution of vertebrates, it is yet unknown how the fidelity of these four molecular biosignatures changes through geological time and with elevated pressure- and temperature-metamorphism of fossils.

Here, I systematically quantify the fidelity (= prediction accuracy) of the biomineralization, tissue identity, metabolic capacity, and relationship signals in a training data set of n=200 carbonaceous fossils that range in age from the

Cambrian to the Recent, detected via Raman and Fourier-Transform Infrared spectroscopy, as a function of geological time, pressure (P), and temperature (T). Simultaneously, changes in the signal abundance of diagnostic molecular heterogeneities are traced in an integrated fossil-based and (*in situ* and *ex situ*) experimental organic P/T phase space, in order to determine minimum thresholds for high-fidelity biosignature detection.

The four biosignatures show different degradation rates of encoded biological information, correlated with the P-/T-stability of their diagnostic molecular features: P- and T-alterations determine the nature of the non-linear loss functions of different types of biosignatures. Notably, time does not have a major impact on biosignature fidelity. Biomineralization and tissue identity signals are most resistant to P-/T-alteration, yielding a high prediction accuracy even in Cambrian carbonaceous compression fossils (P > 0.2 GPa, T > 200°C). Elevated P-/T-conditions have a substantially stronger impact on molecular metabolic and phylogenetic signals. The individual strengths and limitations of each biosignature are showcased with examples from the diverse array of analyzed vertebrate fossils.

Molecular biosignatures preserve paleobiological information in deep time and, thus, represent a powerful tool to address fundamental questions on the evolutionary history of vertebrates, from the Cambrian to the Recent.

Funding Sources J.W. has been funded through the Trimble & Barr Fellowships at Caltech and an Agouron Fellowship at the University of Chicago.

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

THE PHYLOGENETIC RELATIONSHIPS OF CROCODYLOMORPHA: ADVANCES FROM AN EXPANDED PHENOTYPIC SUPERMATRIX

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Crocodylomorpha is a long lived (>230 Ma), diverse clade with an exceptional fossil record. Extant crocodylomorphs are represented by ~30 species with low morphological and ecological diversity, but the diversity of extinct members is vast. The group underwent numerous major habitat transitions, survived multiple mass extinction events, and explored a wide range of dietary niches. Crocodylomorpha has been the focus of modern quantitative phylogenetic analyses for over 30 years, with taxon and character sampling increasing over time. Prior work has elucidated relationships within major groups, but some intergroup relationships remain persistent problems. These include the position of Thalattosuchia, the closest “sphenosuchian” to Crocodyliformes, the position and

relationships of Atoposauridae, and interrelationships of basal neosuchian groups. Part of this instability results from the clade-specific focus of many previous studies. To address this issue, we assembled a supermatrix based on three large datasets with distinct sampling foci: Thalattosuchia, Notosuchia, and Neosuchia. The new dataset is the largest to date comprising 184 taxa scored for 651 morphological characters. All characters were critically reviewed, overlapping characters combined and reconciled, with extensive rewriting adding detail to enhance repeatability in scoring. We analyzed the data in TNT under maximum parsimony (both unweighted and extended implied weighting [EIW]). Resulting topologies recover Thalattosuchia as the sister-group to Crocodyliformes. In addition to “core” notosuchians, Notosuchia includes Peirosauridae and Mahajangasuchidae. Neosuchia remains rather unresolved in unweighted analyses— as a polytomy of otherwise well-resolved clades. Atoposauridae is the earliest diverging neosuchian lineage under EIW. *Calsoyasuchus* is a goniopholidid under EIW but sister to Neosuchia under unweighted parsimony. Additional characters and taxa are being added to test recovered relationships and disentangle the neosuchian topology. The concatenation of largescale matrices is a critical first step to creating the next generation of phenotypic datasets necessary to resolve persistent phylogenetic conundrums. Resolution of the backbone of the crocodylomorph tree is necessary to address major biogeographical questions and examine macroevolutionary phenomena like rates of morphological character evolution and clade diversification dynamics.

Funding Sources NSF DEB 1754596

Technical Session - New Methods (Thursday, November 3, 2022, 10:15 AM)

ANCESTRAL RANGE ESTIMATION OF THE ORDER SQUAMATA USING FOSSIL-INFORMED PHYLOGENIES AND A GEOGRAPHICALLY-INFORMED MODEL

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The order Squamata is a diverse group of reptiles with approximately 10,000 extant species and a relatively good fossil record dating back to the mid Triassic. Although modern squamates have a well-documented, near-global modern distribution, very little is known about the paleobiogeography of squamates in deep time. In our study, we attempt to estimate the ancestral range of Squamata using a biogeographic model that parameterizes the proximity and motion of geographic boundaries over time (called communicating classes) and includes fossils as terminal taxa. This method requires a well-resolved time-calibrated phylogeny. However, there has been major disagreement over the phylogeny of Squamata, especially between molecular and

morphological phylogenies (i.e., the positioning of Iguania, the monophyly of Toxicofera). Therefore, we ran our biogeographic model using three separate phylogenies, two morphological and one molecular, which all feature fossils as terminal taxa. The inclusion of both fossils as terminal taxa and parameters for communicating classes can be contrasted to other biogeographic models (ex., DEC), which can fossils as constraints at nodes and does not have a parameter for communicating classes. Our results show the importance of including fossils in ancestral range estimation for the ability to identify signals that cannot be detected purely by extant data. Our results do have the potential to change as fossils of Triassic and Jurassic squamates continue to be discovered.

Funding Sources Funding was received through the Harlan fund at George Washington University.

Technical Session 15: Theropods (Saturday, November 5, 2022, 8:00 AM)

A NEW SPECIES OF CAENAGNATHIDAE (THEROPODA: DINOSAURIA) FROM THE OLDMAN FORMATION (CAMPANIAN: LATE CRETACEOUS) OF ALBERTA, CANADA

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Caenagnathidae are a clade of oviraptorosaur theropod dinosaurs from the Cretaceous of North America and Asia. Their fossil record is sparse and consists primarily of isolated dentaries or lower limb bones. Their characteristic fused dentaries have been the focus of an extensive body of research on the evolution and ecology of this enigmatic group. Here we provide new stratigraphic and comparative morphological information on TMP 1991.144.0001, a partially complete isolated dentary from Belly River deposits exposed along the Bow River in southern Alberta, approximately 50 km south of Dinosaur Provincial Park. Although this jaw has been previously described in the literature, new stratigraphic data refines the chronostratigraphy of the jaw, increasing its significance. New fieldwork shows that TMP 1991.144.0001 was recovered in the lowermost strata of the Oldman Formation (Belly River Group, middle Campanian, Upper Cretaceous) immediately above the Taber Coal Zone of the Foremost Formation. Previously, all definitive Canadian caenagnathid material was known from either the Dinosaur Park Formation or the Edmonton Group, making TMP 1991.144.0001 the oldest caenagnathid jaw from Canada by at least 2 million years.

Here we provide a new comparative anatomical description of TMP 1991.144.0001, apply 2D geometric morphometrics of caenagnathid dentaries to inform our understanding of the variation within Caenagnathidae, and place TMP

1991.144.0001 in a phylogenetic analysis for the first time. TMP 1991.144.0001 preserves the anterior symphyseal region of the dentary including the complex occlusal surface features characteristic of caenagnathids. However, it differs from other caenagnathids in the presence of deep transversely expanded pits at the anterior end of the labial grooves and the lower relief of the lingual ridges. The 2D geometric morphometric analysis shows that TMP 1991.144.0001 is most similar to *Citipes elegans* and *Chirostenotes pergracilis*. Phylogenetic analysis recovered TMP 1991.144.0001 within a polytomy in the derived Caenagnathinae. Based on the comparative morphology and phylogenetic analysis, TMP 1991.144.0001 may represent a new species of caenagnathid, which is consistent with its stratigraphic position relative to described taxa, and provides new data on the evolution of caenagnathids from a time interval early in their Late Cretaceous radiation.

Funding Sources NSERC Canada Graduate Scholarship-Doctoral awarded to R.D.W.; Royal Society Newton International Fellowship awarded to G.F.; NSERC Discovery Grant awarded to D.C.E.

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

TRIANGULAR BEAST: NEW FOSSILS SHED LIGHT ON *DELTA THERIUM*, AN ENIGMATIC EARLY PALEOCENE MAMMAL FROM NEW MEXICO

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Deltatherium is an early Paleocene (middle Torrejonian NALMA) mammal known only from the San Juan Basin of northwestern New Mexico. *Deltatherium* is a small, spaniel-sized mammal (~ 6 kg). Salient features of *Deltatherium* include a relatively short rostrum and anteriorly shifted orbits, large blade-like upper canines, lack of P1/p1, upper molars with wide styler shelves, buccally projecting para- and metastylar lobes, straight centrocristae oriented mesiodistally, lower cheek teeth with high, pointed cusps, and lower molars with well-developed talonids. The phylogenetic placement of *Deltatherium* is contentious and previous workers have proposed close affinities with tillodonts, pantodonts, and chriacine arctocyonids.

New, relatively complete dental, cranial, and postcranial material allows for a renewed assessment of the functional morphology, phylogeny, life history, and evolution of *Deltatherium*. New specimens include partial braincases and associated middle ear regions and exquisite upper and lower dentitions. These validate the presence of two species of *Deltatherium*; *D. dandraei* and *D. fundaminis*, which form an

anagenic sequence with the former restricted to Tj2-3 and the latter to Tj4-5 of the Nacimiento Formation. Postcranial fossils include portions of axial skeleton, bones of the fore- and hindlimb, tarsals, and phalanges. Histological examination of teeth indicates that *Deltatherium* was precocial.

The new fossils allow an analysis of the functional morphology of *Deltatherium*. It exhibits a suite of features associated with carnivory, including the sabre-like canines, a large sagittal crest and wide zygoma accommodating huge jaw-closing musculature. The low-placed mandibular condyle and relatively small coronoid process, with relatively small lower canines allowed a large gape, consistent with a stabbing function of the upper canines. Loss of the lower molar entoconids may be due to an increasing emphasis on vertical shearing function of the cheek teeth. Features of humerus and ulna indicate relatively unrestricted pronation and supination of the forearm. The tarsus indicates that the ankle was highly flexible. Morphology of the postcrania is consistent with an arboreal or scansorial adaptation.

A phylogenetic analysis based on 2400+ morphological characters and 149 taxa, including 90 Paleogene mammals, run in TNT, results in eight trees. A consensus tree places *Deltatherium* as a basal member of a pantodont plus tillodont clade within crown Placentalia.

Funding Sources ERC starting grant (PalM), no. 756226, NSF Grants DEB 1654949 and 1654952

Technical Session 17: Fish (Saturday, November 5, 2022, 8:00 AM)

A NEW PREDATORY ACTINOPTERYGIAN FROM BLUE BEACH, NOVA SCOTIA

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The Devonian-Carboniferous transition represents a fundamental shift in vertebrate faunal composition (i.e., from placoderms and non-tetrapod sarcopterygians to actinopterygians, chondrichthyans, and tetrapods) and ocean ecology (i.e., reorganization of nekton). Tournaisian-aged strata from Blue Beach and Walton, Nova Scotia capture this moment and yield a diverse fauna of actinopterygians and other vertebrates. Indeed, even partial fossils from these localities preserve critical evidence allowing better understanding of faunal and ecological change. The recent description of the oldest known deep-bodied actinopterygian (recovered from the Early Carboniferous of Walton) provides one example demonstrating postcranial differentiation, the exploration of a new body plan, and functional change, including in locomotory mode. This was surprising, as previous hypotheses of Devonian-Carboniferous faunal

change predicted a homogeneous and morphologically restricted Tournaisian actinopterygian fauna undergoing cranial differentiation, with postcranial differentiation occurring later.

Here, we report an actinopterygian mandible preserved in 3D, representing a new genus and species. This mandible is elongated, gracile, deeply curved upwards, and bears a primary dentition of heterodont fangs. Actinopterygian identity is established by the characteristic ornamentation, dentition, and overall mandible construction observed in the specimen. Mandible length, curvature, and fang morphology combine to produce a functionally differentiated dentition with distinct regions for prey capture and prey processing. Comparison with modern actinopterygians places this taxon as a back-fanged macrodont, distinguishing it from front-fanged macrodont actinopterygians of the Late Devonian. This earliest known instance of back-fanged macrodony in the actinopterygian fossil record provides further evidence of actinopterygian morphological differentiation post-Devonian and implies experimentation in feeding mode. Although this specimen is compatible with previous models of cranial differentiation in Early Carboniferous actinopterygians, we emphasize the function of cranial morphology for feeding in interpreting this specimen and the Devonian-Carboniferous transition in actinopterygians more broadly.

Technical Session 17: Fish (Saturday, November 5, 2022, 8:00 AM)

THE EARLY HISTORY OF ESOCIFORMES (TELEOSTEI) REVEALS CHALLENGES AND OPPORTUNITIES IN THE FOSSIL RECORD OF FRESHWATER FISH

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Esociformes is a geographically widespread lineage of freshwater fish whose crown clade is defined by the split between Esocidae (which includes the extant pike *Esox*, the Alaskan blackfish *Dallia*, and the Olympic mudminnow *Novumbra*) and Umbridae (a group consisting of the three living species of North American mudminnow classified within *Umbra*). Current estimates place the origin of crown Esociformes in the late Cretaceous with the implication that at least two esociform lineages (i.e., the total groups of both Esocidae and Umbridae – Pan-Esocidae and Pan-Umbridae, respectively) survived the Cretaceous/Paleogene (K/Pg) mass extinction event. Newly recovered esociform material from late Cretaceous (Maastrichtian) sediments of the Williston and Denver Basins of North America provided the impetus to test this origin hypothesis, which we did using a global phylogenetic approach. Results indicate that characters historically relied upon to identify esociform fossils, and that

currently serve as the foundation for a Cretaceous origin of the group, evolved along the esociform stem lineage and thus cannot discriminate between crown and stem forms.

Combining the empirical record with this conceptual framework establishes the earliest definitive evidence of crown Esociformes in the Cenozoic thereby lengthening the esociform stem lineage and extending it across the K/Pg boundary.

With the exception of several famous localities, and in contrast to that of marine lineages, the post-Paleozoic fossil record of freshwater fish is dominated by isolated and fragmentary elements recovered using screen-washing techniques. This reality makes our understanding of the deep history of freshwater lineages especially vulnerable to investigator differences regarding the theory and practice of fossil identification. Building on our esociform study, we explore the challenges and opportunities that a unified approach could bring to the study of these important fishes, with special emphasis on resolving the role of the K/Pg extinction event in shaping the modern fauna.

Symposium: International Community Connections
(Wednesday, November 2, 2022, 1:45 PM)

#SCICOMM IN THE CLASSROOM: AN ONGOING STORY OF TRIAL AND ERROR, PROFESSIONAL DEVELOPMENT, AND BUILDING A FOUNDATION

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There is a rising need for effective science communication in today's connected, global society, and the need for public engagement with science is arguably most apparent on online platforms. More than half of the world's population is a digital native (millennial or younger) demanding and supplying online engagement. As a result, #SciComm is growing across social media platforms. The academic literature on teaching informal SciComm is significantly lagging online SciComm engagement itself, and the limited number of studies report ambiguous results regarding teaching effectiveness. Because so much anecdotal information from active members of online SciComm communities emphasizes "learn by doing", an easy first step in developing student skills in informal SciComm is to incorporate both formative and summative assessments into classroom activities. Here, examples of assessments used in upper-division paleontology courses serve as a case study for integrating informal SciComm practice in a formal classroom setting. Formative assessments include ungraded class participation in targeted social media events for Darwin Day and/or National Fossil Day. Summative assessments include annotated bibliographies in Twitter format, multi-platform social media posts summarizing research presentations, and constructing blog posts on paleobiology topics written for a general audience. In some courses, class time was dedicated to discussions and readings on SciComm. Student feedback

acknowledges the importance of SciComm engagement via social media and that informal SciComm experience plays an important role in student professional development. However, student responses also highlight the need for more in-class background context to prepare students for assessments and application. Secondary benefits of these informal SciComm activities include engaging assessments that do not result in significant instructor workload, yet offer students an opportunity to practice clear, concise writing. Adding SciComm assignments to established classes provides a unique way to assess science communication for course, program, or department outcomes. Additionally, social media assignments increase personal, lab, and/or department social media traffic, thereby increasing visibility, impact, and recruitment. Next steps include revising assessments based on feedback and collecting more rigorous qualitative and quantitative data on formalized SciComm instruction effectiveness.

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

A NEW CATURID (HOLOSTEI: HALECOMOPRHI) FROM THE UPPER JURASSIC OF BRUNN (BAVARIA, GERMANY)

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Caturidae (Holostei: Halecomorphi) is an extinct family of small to relatively large sized fishes. They are known mainly from the Jurassic, but range from the Upper Triassic to the Lower Cretaceous. Despite previous taxonomic revision of these fishes, there remains a lack of clarity about the morphological differences between the species. As part of a thorough taxonomic revision of this group, a large, as of yet unstudied, caturid specimen from the late Kimmeridgian locality of Brunn (Bavaria, Germany) is being researched for this study. The locality of Brunn has a rich vertebrate fauna and it represents the second oldest known locality within the Solnhofen Archipelago. A detailed morphological analysis is conducted to assess the systematic position of this specimen. Our observations point to a close resemblance to one other caturid specimen from the late Kimmeridgian of Cerin (France) in particular. The new fish differs from other (mostly Tithonian) caturids in terms of its tooth morphology and the number of vertical scale rows and represents a new taxon. Clarifying the systematics of the new taxon will contribute to the understanding of the palaeobiodiversity in Brunn. Because of its place as one of the oldest localities within the Solnhofen Archipelago, increased knowledge of its palaeobiodiversity will aid in understanding the evolutionary history of caturids in particular, and the origins of the (marine) faunas of the Solnhofen Archipelago in general. Recent studies suggest that the actinopterygian fauna of Brunn is more similar to that of the Kimmeridgian of Cerin (France) than to geographically

closer Tithonian basins within the Solnhofen archipelago such as Solnhofen and Eichstätt (both Bavaria, Germany). These stratigraphic differences, being more notable than geographic differences, point to an actinopterygian faunal turnover between the late Kimmeridgian and the early Tithonian. The close resemblance between the two aforementioned caturids from Brunn and Cerin is congruent with this hypothesis.

Funding Sources Deutsche Forschungsgemeinschaft: LO1405/6-1 (ALA).

Technical Session 7: Paleogene Mammals & Primates & Carnivora (Thursday, November 3, 2022, 1:45 PM)

A REASSESSMENT OF *MIRACINONYX TRUMANI* AND *PUMA CONCOLOR* OCCURRENCES IN THE FOSSIL RECORD OF PLEISTOCENE NORTH AMERICA

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The American cheetah (*Miracinonyx trumani*) is an extinct cat from the Pleistocene of North America closely related to the extant mountain lion (*Puma concolor*). While *M. trumani* has previously been known from only a handful of localities, its morphological similarities with *Puma* combined with a lack of historical recognition suggest that it may be more widespread in the fossil record than previously realized, suffering from frequent misidentification as *Puma*. Indeed, many Pleistocene *Puma* are described from material more closely matching the description of *M. trumani*. For this study we undertook a systematic review of Pleistocene *Puma* and *Miracinonyx* material in museum collections representing sites across North America with the aim of identifying overlooked *Miracinonyx* occurrences. We took morphological measurements of cranial and postcranial elements of ostensibly recognized Pleistocene *Puma*, known *Miracinonyx*, and recent *Puma* specimens to construct a robust data set of size and proportion ranges from these populations and for comparison against previously published data sets. These measurements were statistically analyzed using a Student's t-test in order to determine whether *Puma* and *Miracinonyx* specimens significantly differ from one another. Discriminate function analysis was performed in order to differentiate specimens of uncertain affinity, and principal component analysis was used to examine variance within and between populations. Results reveal the first in-depth reexamination of several fossils which were previously identified as extinct *Puma* and which instead represent *M. trumani*, including material housed at the University of California Museum of Paleontology from Rancho La Brea and McKittrick tar seeps. We have also identified the first known occurrence of *M. trumani* material in Mexico, a mandible, ulna, and tibia from San Josecito Cave in the state of Nuevo León housed at the Los Angeles County Museum of Natural History. Our statistical analyses suggest Pleistocene *Puma* were larger than extant populations and co-occurred with *M.*

trumani in several localities. This study expands the known biogeographic range of *M. trumani* and our understanding of the evolution and paleoecology of both *M. trumani* and *Puma* in Pleistocene North America, suggesting *M. trumani* occurred in a wider range of habitats than previously recognized and may have partitioned some of these habitats with *Puma*.

Technical Session 10: Soft Tissues & Taphonomy (Friday, November 4, 2022, 8:00 AM)

PREDICTING PATTERNS OF VERTEBRATE FOSSIL PRESERVATION USING VARIATION IN RATES OF STRATIGRAPHIC ACCUMULATION: A CASE STUDY IN A MAMMAL-RICH INLAND BASIN (WASHAKIE FORMATION, WY)

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Paleontologists typically prospect for well-preserved, taxonomically identifiable fossils by seeking fine-grained floodplain deposits or other low-energy facies. However, predicting the specific beds among such deposits that will yield fossils ideal for the project at hand remains difficult. We hypothesized that the degree of fragmentation and abundance of fossils should vary with respect to rates of rock accumulation, determined by the supply of siliciclastic sediment into the basin and the basin's availability to store that sediment (accommodation). Settings with high rates of both accommodation and sediment supply would permit rapid burial and thus be most inclusive of large-bodied animals and articulated specimens, whereas if accommodation is high but sediment supply is low, complete burial would occur less frequently, with only occasional preservation of small material expected. Low rates of accommodation should limit preservation potential regardless of sediment supply, given greater erosional reworking and fragmentation of deposited floodplain assemblages, and the only taxonomically identifiable material should be small, durable material.

We tested this hypothesis using measured sections of the middle Eocene Washakie Formation in Wyoming (50-46 Ma). Relative changes in rates of accommodation (A) and sediment supply (S) were determined using lithologic evidence such as the frequency of lacustrine facies, multi-story sandstones, and mature paleosols. We find that the Washakie Fm. exhibits mostly high-A/low-S supply conditions in its basal Kinney Rim Member (KR), followed by high-A/high-S conditions during the lower and middle Adobe Town Members (AT1 and AT2), and a strong decrease in accommodation with moderate-high sediment supply in the upper Adobe Town Member (AT3). New material from pilot fieldwork in 2021 was combined with data from Field Museum collections to compare preservation. We found a strong pattern linked to this three-phase history of rock accumulation: several concentrated assemblages of exclusively small mammals in the KR,

abundant large mammals and some articulated small mammals in the AT1 and AT2, and highly fragmented, sparsely distributed small mammals in the AT3. The rate of rock accumulation, rather than facies alone, plays a strong role in determining the composition and nature of mammal assemblages in this inland basin, providing insight for prospecting and understanding the occurrence of fossils in fluvial records.

Funding Sources This work was funded by the University of Chicago's Department of the Geophysical Sciences and the Society for Sedimentary Geology (SEPM).

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

SALAMANDERS (URODELA) FROM THE LATE MIOCENE TYNER FARM FOSSIL LOCALITY, ALACHUA COUNTY, FLORIDA

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Tyner Farm is an early Hemphillian (Hh1) fossil locality located in Alachua County, Florida, discovered in 2001. Numerous fossils from various large and mid-sized mammals have been identified and catalogued. The microfauna, despite being among the richest and best preserved for any Hh1 site, has remained largely overlooked however. Thus, a detailed study of the Tyner Farm microvertebrates is necessary to help fill in the gaps in our understanding of the evolution and diversity of the smaller-bodied taxa from this time period while providing important paleoecological information. Among the particularly abundant herpetofauna, the salamanders are represented by four genera (*Ambystoma*, *Notophthalmus*, *Pseudobranchius*, and *Siren*) from three families (Ambystomatidae, Salamandridae, Sirenidae respectively). The dominance of *Ambystoma*, a mostly terrestrial taxon, supports early interpretations of Tyner Farm being a woodland habitat with a pond or slow-flowing creek in which to breed. The more aquatic salamander genera *Notophthalmus*, *Pseudobranchius*, and *Siren* are much less numerous and could be evidence of the presence and periodic flooding of a larger, nearby water body. Salamanders are generally rare in the fossil record and the *Ambystoma* fossils from Tyner Farm represent the oldest remains of the genus east of the Mississippi River.

Funding Sources NSF-CSBR

Technical Session 1: Dinosaurs (Wednesday, November 2, 2022, 8:00 AM)

OSTEOLOGY AND KINEMATICS OF THE PACHYCEPHALOSAURID VERTEBRAL COLUMN

PROVIDES FURTHER EVIDENCE REFUTING THE AGONISTIC HEAD-BUTTING HYPOTHESIS

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The thickened frontoparietal dome of pachycephalosaurids has long been hypothesized to have allowed for bighorn sheep-like head-butting. Previous postcranial support for this hypothesis were their dorsal vertebrae, which bear anteroposteriorly oriented corrugations on the zygapophyseal facets; suggestive that these structures distributed forces from high-velocity cranial impacts. However, the head-butting pachycephalosaurid hypothesis is currently the subject of great debate.

Dorsal vertebrae from a new specimen of *Pachycephalosaurius wyomingensis* were 3D scanned, retrodeformed, and kinematically modeled to calculate range-of-motion (rom) to assess the functional role of these zygapophyseal corrugations. Additionally, the presence of corrugated zygapophyses was examined in extant taxa; however, the only clade found to possess this feature was Macropodidae. In comparison to the bighorn sheep, the *Pachycephalosaurius* and the kangaroo had rom far more similar to one another. Dorso- and ventroflexion averaged 7° and 7.6° in the bighorn sheep, 10.9° and 5.6° in the kangaroo, and 9° and 3.8° in the *Pachycephalosaurius* respectively. However, the most notable rom difference was lateral flexion, with an average of 4.3° in the bighorn sheep, versus 1.8° in the kangaroo and 2.5° in the *Pachycephalosaurius*. This rom assessment supports hypotheses that the corrugated zygapophyses severely limit lateral flexion. Additional examination reveals that the *Pachycephalosaurius* bears none of the vertebral morphologies of the bighorn sheep, yet it shares numerous vertebral, pelvic, and caudal morphologies with the kangaroo.

In the kangaroo, these structures allow for tripodal posturing and kickboxing behavior. While a kangaroo-like, tripodal pachycephalosaurid may sound novel, this concept originated in the 1970s. These convergent structures, along with the kinematic assessment, supports the hypotheses that pachycephalosaurids likewise engaged in tripodal posturing, and possibly even a similar kickboxing behavior. The iconic domes of pachycephalosaurids could have certainly been used in low-velocity pushing or shoving matches; however, in combination with the previous debated cranial features, this analysis finds that the postcranial skeleton argues against high-velocity, *Ovis*-like head-butting. Together, this study aids in creating a revised view of pachycephalosaurids more in line with historic reconstructions, and making this already unusual dinosaurian clade even more bizarre.

Technical Session 10: Soft Tissues & Taphonomy (Friday, November 4, 2022, 8:00 AM)

METRICS OF SKELETAL RECORD COMPLETENESS REVEAL THE EXISTENCE OF A “PHYLOGENETIC LAGERSTÄTTEN” EFFECT IN THE UPPER CRETACEOUS AEOLIAN DEPOSITS OF THE GOBI DESERT

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Localities that yield exceptionally preserved fossils (i.e., lagerstätten) also yield unparalleled details concerning ancient organisms’ anatomy, physiology, ecology, behavior, and surrounding ecosystems. These taphonomic anomalies, which occur mostly in low-energy and/or anoxic/hypoxic depositional settings in deep marine, coastal lagoonal, and lacustrine environments, often hold an outsized influence over our understanding of regional and global biodiversity patterns in the rock record (i.e., the “lagerstätten effect”). In this study, we use an established fossil completeness metric to quantify the “lagerstätten effect” on the amount of phylogenetic information available in the fossil record of squamates (e.g., lizards, snakes, amphisbaenians, and mosasaurs). We use published descriptions of 797 fossil squamate species and 16,983 corresponding specimens spanning 242 million years of the group’s evolutionary history. We find that, in addition to traditional lagerstätten deposits (marine chalks, hypersaline lagoons, lacustrine), the aeolian deposits of the Late Cretaceous Gobi Desert of Mongolia and China preserve exceptionally complete squamate anatomical and phylogenetic data. We show that unlike traditional lagerstätten deposits, the extraordinarily diverse Gobi fossil squamate record has an anomalously large influence over fossil record completeness on continental/global scales, both through geologic time and compared to all other depositional settings containing squamate fossils. We also find that squamate species from the Late Cretaceous Gobi make up close to 50% of all fossil taxa incorporated into multiple phylogenetic analyses examining higher-level squamate evolutionary relationships. We use the distinctive qualities of the Gobi squamate assemblage to establish observable criteria for a “phylogenetic lagerstätten effect”, chiefly: 1) phylogenetic lagerstätten tend to preserve high levels of skeletal anatomy and high levels of taxonomic diversity; and 2) more taxa from phylogenetic lagerstätten tend to get incorporated into phylogenetic analyses. These results expand the definition of exceptional preservation beyond strictly taphonomic constraints, and invite further taxon-specific assessments of the availability of important evolutionary information in the rock record.

Symposium: International Community Connections
(Wednesday, November 2, 2022, 1:45 PM)

USING INTANGIBLE FOSSIL ALTERNATIVES WHEN DESIGNING EXHIBITS – A CASE STUDY OF A PALEOHISTOLOGY ART GALLERY

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When generating new exhibitions, natural history curators target tangible fossil specimens as the primary appeal. Education and outreach programs focus on original specimens as learning objects. However, this is inherently limiting, particularly for smaller institutions that may not have adequate access to fossils and/or the facility to securely display them.

Here we present an alternative approach by broadening the definition of learning object through integration of natural history and art education in the space of an academic art gallery. *Lost Worlds: Microphotography of Extinct Species* is a paleohistological art gallery exhibition that showcases the work of ten early-career researchers through a series of framed prints. Images were chosen on the basis of viewable microanatomy, taxonomic diversity through deep time, and artistic concepts. As art objects, the product of natural staining from infiltrated sediment, and the laboratory process behind the creation of paleohistological thin-sections offer the aesthetic experience of visual contrast, color relationships, and structural patterns. The natural history component integrates the science behind each image, providing the audience with microscopic snapshots of anatomical knowledge from active research. Regular tours are offered alongside an array of public events including seminars, movie screenings, Q/A sessions with paleontologists, artist in residence, and family-oriented activities.

As an art gallery exhibition, *Lost Worlds* encourages the viewer to consider the visual impact of the photographic images in light of the scientific inquiry and provided via short captions and 3D printed objects. Although a similar model is employed by natural history museums, visitor feedback has indicated that this coalescence of science and art using intangible fossil specimens provides an additional level of non-directed expression and immersion. Additionally, it has proved accessible to social and traditional media outlets that might not have otherwise shown interest in a strictly science- or art-centered exhibition.

We hope that this successful, low-cost case study provides a model framework and encourages paleontologists to look beyond the customary exhibit comprised of tangible fossil specimens. By expanding into other avenues of our research (e.g. histology, CT scanning, SEM), we can make a significant step towards broadening and increasing the effectiveness of our research through accessible outreach.

Funding Sources Misericordia University - Pauly Friedman Art Gallery, Misericordia University - College of Arts and

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

MAMMALS OF THE TURING PIT LOCALITY, MONONA COUNTY, IA: IMPLICATIONS FOR AGE AND PALEOENVIRONMENT

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The Turin Gravel Pit locality in Monona county, Iowa has been known to paleontologists since 1909 (then as Elliott pit), yet has seen little recent research. The age of Turin is unclear. Early paleontologists used the outdated term “Aftonian” hinting at an early Pleistocene age, but later comparisons to assemblages dating to the last glacial period (i.e. “Wisconsin”) argue for a much younger age. This study provides a more comprehensive mammalian faunal list, and uses known age ranges of identified taxa to estimate the age of the site. These data potentially document new geographic or temporal range extensions of identified taxa. Based on the presence of *Mammuthus*, the lack of *Bison*, and the reversed till deposit located stratigraphically above fossil-bearing deposits, the current hypothesis is that Turin belongs to the Irvingtonian (North American Land Mammal Age), ~0.780-1.8 Ma. Mammalian taxa include: *Equus*, Camelidae, Cervidae, Ovivovini, Tayassuidae, *Megalonyx*, *Geomys*, *Sylvilagus*, *Castor canadensis*, *Castoroides*, *Ondatra*, *Panthera*, *Canis*, and *Vulpes*. The majority of vertebrate fossil sites in Iowa are Rancholabrean or Holocene in age, so Turin has the potential to be one of the oldest Cenozoic localities in the state. Fossil mammals from Turin fill a gap in our understanding of regional biogeography.

Virtual Posters

A NEW BASAL CROCODYLOMORPH (ARCHOSAURIA: CROCODYLOMORPHA) FROM THE UPPER TRIASSIC OF TEXAS, USA

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In 2005, a field team from the Museum of Texas Tech University explored the bone bed of Late Triassic reptiles in Garza County, northwest Texas. Douglas Cunningham, one of

the co-authors of this report, discovered and excavated the remain of an archosaurian from the Bull Canyon Formation of the Dockum Group. Here we report our preliminary study of the new archosaurian, represented by a mostly associated partial skeleton. This archosaurian can be assigned to Crocodylomorpha based on the absence of the descending process of the squamosal, the elongation of the radiale, and the presence of a rod-like posteromedial process of the coracoid. It can be distinguished from other crocodylomorphs by a set of characters. The most striking of those characters include that (1) the antorbital fossa of the skull cannot be well defined anteriorly and anteroventrally, (2) the facial portion of the maxilla anterior to the anterior edge of the antorbital fenestra is about twice as short as the portion posterior to the anterior edge of the fenestra, (3) the first three pairs of dorsal osteoderms are small and rhomboid in outline, (4) paramedian dorsal osteoderms lack an anterolateral process, (5) the axial neural spine is low and does not rise upwards posteriorly, (6) the long preacetabular process of the ilium is bar-like and mediolaterally flattened, and (7) the ventral margin of the iliac acetabulum is very convex. Our preliminary phylogenetic analysis does not support the monophyly of Sphenosuchia, which traditionally includes all non-crocodyliform crocodylomorphs, and further suggests that the new crocodylomorph, with other three North American taxa (*Hesperosuchus*, *Dromicosuchus*, and *Kayentasuchus*) and a European taxon (*Saltoposuchus*), may form a clade among basal crocodylomorphs. In addition, the discovery of the new crocodylomorph not only expands the geographic range of basal crocodylomorphs in North America but also implies that basal crocodylomorphs may have dispersed to Europe after two separate deviate events.

Funding Sources RCP09 from Canadian Museum of Nature; IOB-0517257, IOS-1050154, & IOS-1456503 from NSF; 2021-02973 from SRC; P. W. Horn Professor research grants, Texas Tech University

Technical Session 15: Theropods (Saturday, November 5, 2022, 8:00 AM)

TOOTH REPLACEMENT AND RESORPTION PATTERNS OF A JAW WITH TROODONTID CHARACTERS FROM MONGOLIA PROVIDE INSIGHT INTO EVOLUTION OF THE THEROPOD TOOTH REPLACEMENT PROCESS

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Reptilian polyphyodonty and their tooth replacement process has spurred great interest since the 1960s. Archosaurian tooth replacement and tooth cycles have shown a great variety of a generally similar process among different lineages, indicating modification to a conserved regulatory network. Earlier comparison of the tooth replacement process of non-avian theropods, namely *Coelophysis*, *Allosaurus*, and *Gorgosaurus*,

showed a resorption pattern different from what we observed in toothed birds and modern crocodylians. In these non-avian theropods, the tooth buds in the early stages of their tooth cycle developed in replacement crypts in the lingual alveolar walls. By contrast, the tooth buds of the toothed stem birds developed completely in the alveoli, migrated labially and resorbed into the root of their predecessor at their early stages, and showed no sign of resorption on the alveolar walls. These features at the early stages of the tooth cycle of the stem birds are similar to those that have been observed in American alligators (*Alligator mississippiensis*). However, the disparity between the studied non-avian theropods and stem birds requires investigation into taxa filling the phylogenetic gap between these two groups. Here we present a high resolution μ CT scan result showing tooth replacement and resorption pattern of a lower jaw with troodontid characters from Mongolia. The high resolution scan result reveals resorption on both the lingual alveolar walls and the roots of the mature teeth. This phenomenon seems to be intermediate between the previously studied non-avian theropods and toothed stem birds, which coincides with the phylogenetic relationship between these three groups (*i.e.*, tyrannosaurid and more ancestral non-avian theropods, troodontids, and stem birds). Each tooth position of this lower jaw developed in its alveolus separated by interdental septa. Although there are clear signs of resorption on the alveolar walls, the early-stage tooth bud appears to develop in the alveolus and didn't form a prominent "crypt" in the alveolar wall. There are also clear signs of resorption on the lingual roots of the earlier teeth when the early-stage teeth are present. This intermediate state of the tooth replacement process may represent a transition from an ancestral mode to a crown-ward theropod tooth cycle, and marks a crucial link of a gradual driver that controls the resorption patterns.

Regular Poster Session 2 (Thursday, November 3, 2022, 4:30 - 6:30 PM)

A NEW MICROVERTEBRATE ASSEMBLAGE FROM THE UPPER CRETACEOUS (EDMONTONIAN) WILLIAMS FORK FORMATION, NORTHWESTERN COLORADO, USA, AND THE TAPHONOMY OF WILLIAMS FORK FORMATION VERTEBRATES

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Nonmarine Upper Cretaceous microvertebrate assemblages of Laramidia tend to be either Judithian (~middle Campanian) or Lancian (latest Maastrichtian) in age. Assemblages of Edmontonian (late Campanian-middle Maastrichtian; including the "Kirtlandian") age are much less numerous, but

important as they document the transition from diverse Judithian assemblages to Lancian ones. ReBecca's Hollow is a microvertebrate fossil site in the lower half of the Williams Fork Formation (WFF; part of the Mesa Verde Group) in northwestern Colorado. Surface collections from ReBecca's Hollow are predominantly cm-scale shell fragments of trionychid turtles and lepisosteid (gar) scales, but include several other taxa represented by fragments. Preliminary screen washing and careful surface collection of microvertebrates has resulted in the recovery of several hundred more mm-scale specimens. The combined ReBecca's Hollow assemblage thus far includes osteichthyans (bony fish), possible amphibians, turtles, crocodiles, dinosaurs, and mammals. Osteichthyans are represented by numerous scales, vertebrae, and teeth of gars, several amiid teeth, and at least two pycnodontid pharyngeal teeth. Reptiles include turtles and crocodylians, the latter represented by osteoderms, vertebrae, skull fragments, and many teeth, some of which are robust (durophagous) and considered aff. *Brachychampsia* sp. Some fragmentary osteoderms may pertain to lepidosaurs. The dinosaurs consist of hadrosaurs, theropods, and possibly ceratopsians, all identified from small teeth. Mammals are represented by an upper right molar of *Alphadon* sp.

To date, the mudstone-hosted ReBecca's Hollow locality lacks chondrichthyans, but rays and other sharks are a relatively common component of nearby sandstone-hosted assemblages. Existing cataloged collections from the WFF are strongly biased towards mammals and dinosaurs, rendering comparisons complex. We interpret ReBecca's Hollow as a floodplain deposit based on the occurrence of the fossils in a drab mudstone with some pedogenic nodules; similar to some other known sites (e.g., "Dinomunge"). Other taphonomic modes in the WFF include more carbonaceous shales, interpreted as bogs, oxbows, and bayous (e.g., "Dragonview" microvertebrates) and sandstone and intraformational conglomerates channel deposits that have yielded the known dinosaur skeletons and diverse microvertebrates (e.g., Carrotman, Arrowhead, J&M site).

Funding Sources Appalachian State University Department of Geological and Environmental Sciences and Office of Student Research

Colbert Prize Session

PATTERNS OF MACROWEAR ON IN SITU TYRANNOSAURID DENTITIONS FROM THE UPPER CRETACEOUS OF NORTH AMERICA

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Tooth macrowear is a general term for tooth abrasion visible with the naked eye. Because such abrasion is produced

primarily by tooth-tooth and tooth-food contact, analysis of observed macrowear patterns can provide information regarding diet and feeding behaviour. Macrowear analyses have been conducted for various vertebrate taxa ranging from mammals to dinosaurs, including tyrannosaurids. However, previous studies of tyrannosaurid macrowear were limited to isolated teeth from the Upper Campanian of Alberta. To expand our current understanding of tyrannosaurid jaw mechanics, we conduct a survey of macrowear on in situ teeth preserved in tyrannosaurid specimens from the Upper Cretaceous of North America. Macrowear was separated into three categories: (1) facets (smooth, flat, typically oval-shaped surfaces with or without fine-scale scratches); (2) spalling (removal of enamel with minor modification of the overall tooth shape); and (3) breakage (major modification of overall tooth shape with subsequent smoothing/wear). Enamel spalling at the tooth tip and along the mesial carinae was the most commonly observed type of wear, consistent with the frequent contact of this surface with flesh and bone during biting. Facets most commonly occur on the lingual surfaces of maxillary and premaxillary teeth, and the labial surfaces of dentary teeth. This is likely due to contact between the upper and lower tooth rows, and continuous repetitive movement of these teeth in opposing directions. Wear facets and spalling were relatively prevalent on the labial surfaces of the premaxillary teeth, suggesting that these teeth may have been used to ‘nip’ at the last scraps of flesh remaining on carcasses. The high incidence of breakage in distal teeth suggests these teeth were used for processing durable materials such as bone. The results of this study thus support previous research suggesting that tyrannosaurid heterodonty reflects variation in tooth function along the jaw.

Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

LATE NEOGENE CRICETID RODENT REMAINS FROM THE GRAY FOSSIL SITE OF EASTERN TENNESSE

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The Cricetidae are the second-most species-rich family of mammals and are common in terrestrial habitats of most continents. While this group of rodents had experienced explosive growth in North America since the Late Eocene and is well-represented in fossil assemblages in the west, few records have been found and studied from terrestrial sites in eastern North America. As one of the rare Pliocene terrestrial sites discovered in the east, the Gray Fossil Site (GFS) of Tennessee has produced a diverse assemblage of vertebrate fossils, and large mammals have received the most research attention. Screen-washing of sediments at the site has yielded many small mammal specimens, but they have largely remained understudied. This project uses qualitative and quantitative methods to examine the morphology of fossil

cricetids from GFS, particularly focusing on molar and jaw elements owing to their abundance and the rich taxonomic and ecological information they provide. Materials have been studied under a stereomicroscope and photographed using a digital microscope camera, with morphology compared to modern species and published records of cricetids. Specimens from GFS include several neotomine taxa, *Symmetrodontomys*, and *Postcopemys*, which is the most abundant taxon at the site. While many cricetid specimens have been recovered and identified from GFS, no arvicolines have been found. Distinctive morphological features seen in some specimens suggest the presence of new cricetid species. The array of cricetids present is divergent from those at contemporaneous sites and reinforces the spatial and temporal uniqueness of the Gray Fossil Site. Situated in what is a present biodiversity hotspot in the Appalachian region, GFS provided habitats for cricetid taxa with diverse body sizes and dietary preferences in the Pliocene.

Virtual Posters

A MIDDLE TRIASSIC PREDATOR ECOSYSTEM WITH HIGH BIODIVERSITY IN A NONMARINE SETTING REVEALED BY VERTEBRATE COPROLITES FROM THE ORDOS BASIN, CHINA

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Coprolites (fossilized faeces) are a valuable palaeobiological source for interpreting the diet and feeding behaviours of the host animals, and thus for reconstructing predator-prey interactions of a palaeoecosystem. Here we investigated the external morphology, food inclusions and geochemical composition of vertebrate coprolites from organic-rich lacustrine sediments of the Chang 7 Member, in the Bawangzhuang section, Tongchuan City, Shaanxi Province, China. We assigned various producers to coprolites in different morphology using multiple proxies: three heteropolar spiral coprolites derived from three types of hybodonts, two amphipolar spiral coprolites from coelacanth or *Saurichthys* with simple spiral valves, and non-spiral coprolites from *Pseudosuchia* and predatory actinopterygians. Evidence from vertebrate coprolites shows that the Ordos Basin in the Middle Triassic was populated by highly diverse animal communities occupying terrestrial, semi-aquatic and aquatic realms, where predation was common.

Funding Sources National Natural Science Foundation of China (No. 41876124, 42172009), and State Key Laboratory of Shale Oil and Gas Enrichment Mechanisms and Effective Development.

Symposium: A Late Miocene Shangri-la (Wednesday, November 2, 2022, 1:45 PM)

THE EVOLUTIONARY AND BIOGEOGRAPHIC SIGNIFICANCE OF THE COLOBINE MONKEY, *MESOPITHECUS PENTELICUS*, AT SHUITANGBA LOCALITY, CHINA

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The colobine genus *Mesopithecus* represents one of the most geographically widespread and well-known nonhuman fossil primates, spanning a period from the early late Miocene until the early Pliocene. Currently, fossil finds range from western Europe, eastwards to the Balkans and further east to Iran and Pakistan. The recent description of a dentate mandible, a proximal femur, and a complete calcaneus, attributed to *Mesopithecus pentelicus* Wagner, 1839, from the Shuitangba lignite mine in Zhaotong Prefecture, northeastern Yunnan Province, China, extends further eastwards the range of the genus and reinforces its great capacity of dispersal. The dietary flexibility and locomotor versatility of *Mesopithecus* most likely enabled this migration eastwards via the use of extended suitable habitats, such as mixtures of woodlands and more open biomes. This dispersal may have been continuous or episodically rapid and occurred during a period of dramatic ecological, floral, and faunal changes in Eurasian terrestrial ecosystems at the end of the Miocene. At Shuitangba, *M. pentelicus* lived in a seasonal freshwater-margin forested environment, with cool, dry winters and warm, wet summers. Its diet most likely relied on leaves, nuts, and seeds, and it mainly exploited the tree canopy via quadrupedal walking and leaping, and probably occasionally the herby and shrubby understory. Its presence in this region of southwest China near the end of the Miocene further attests to the ecological versatility of the species and its successful exploitation of varied habitats. It is very likely that subsequent habitat changes towards even more seasonal and drier conditions promoted rapid diversification events that led to the evolution of some (odd-nosed) or all Asian colobines.

Funding Sources BCS 1035897, 1227964, 0321893, 1227927; Yunnan NSF, Government of Zhaotong 2010CC010; IVPP; National NSF, China 41430102; Governments of Zhaotong and Zhaoyang

Virtual Posters

DISTRIBUTION AND TOOTH MORPHOGUILDS OF MOSASAURIDS (SQUAMATA) OF THE CAMPANIAN WESTERN INTERIOR SEAWAY WITH IMPLICATIONS FOR CONTROLS ON MOSASAUR PALEOBIOGEOGRAPHY

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The Western Interior Seaway (WIS) of North America is well known for its mosasaurid squamate diversity, particularly during the Campanian of the Late Cretaceous. This diversity has historically been examined at a fine scale, with many studies investigating the faunal composition of specific assemblages. Mosasaur tooth morphology has also been extensively studied, with tooth characteristics commonly being used as both phylogenetic and diagnostic characters. However, many studies examining mosasaur communities and tooth morphology have been focused on a broader spatiotemporal/phylogenetic scale or on assemblages outside of the WIS. This study investigates the spatial distribution and morphological disparity of Campanian WIS mosasaurs in relation to potentially limiting biotic and environmental factors as well as the importance of online, collections-based resources for paleontological data. Over 600 Campanian mosasaur occurrences recorded in online databases were categorized according to taxonomic rank and plotted on reconstructed paleogeographic maps. Plioplatecarpines, the most latitudinally widespread clade, and mosasaurines each constitute approximately 38% of the total mosasaurid species number within the seaway; in contrast, tylosaurines are less common and halisaurines are scarce. Tooth morphoguilds indicative of feeding adaptations were also assigned to each taxon based on preexisting literature and novel measurements of tooth dimensions. The majority of Campanian WIS mosasaurids are found to belong to the 'Cut' guild. Mosasaurines display the highest amount of tooth disparity, with some guilds having a more spatially limited distribution potentially related to a combination of biotic and environmental factors. Many aspects of mosasaur paleoecology and evolution are still poorly understood and, as this study relies on the data available in online databases, further additions to and expansions of these databases will help create a more complete picture of mosasaur paleobiogeography within the WIS.

Regular Poster Session 4 (Saturday, November 5, 2022, 4:30 - 6:30 PM)

NEW INFORMATION ON THE ENIGMATIC *WYOLESTES* AND THE AFFINITIES OF THE GENUS

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Wyolestes is a rare mammal from the early Eocene of North America. The relationships of the genus have been unclear, with proposed affinities to mesonychia, didymoconids, and

hyaenodontids. A partial skeleton of *Wyolestes apheles*, including a nearly complete skull, was preliminarily reported almost two decades ago, but carbonate matrix obscured many critical aspects of the morphology of the specimen. We present an update on the morphology and affinities of *Wyolestes* based on digital preparation of the skull and parts of the limbs of this specimen using micro-CT data. Two previously unreported specimens, one of *W. apheles* and one of *W. dioctes*, provide additional information on the morphology of *Wyolestes*, as does previously undescribed material of the type specimen of *W. iglesius*.

The skull of *Wyolestes* is narrow and elongate, particularly the rostrum, with an elongate but small gauge infraorbital canal and a weak zygomatic arch. Internally, the skull has an ossified tentorium, a distinctive feature shared with pangolins and many carnivorous eutherians. Basicranial morphology is unspecialized, with the most distinctive feature being an excavation at the anterior tip of the promontorium, likely to accommodate the internal carotid artery as it approached the piriform fenestra. There is no evidence for an expanded, pneumatized ear cavity as occurs in didymoconids. An ossified auditory bulla is not preserved, nor is there evidence for its attachment.

The postcranial skeleton of *Wyolestes* shows some features consistent with digging, including an elevated humeral deltopectoral crest and elongate, deeply fissured unguals, but *Wyolestes* lacks the more substantial adaptations to a fossorial lifestyle present in Didymoconidae. Fossorial adaptations that are present are concentrated in the forelimbs and may indicate some capacity for scratch digging. The totality of the postcranial morphology of *Wyolestes* suggests a generalized terrestrial locomotor repertoire, broadly comparable to some early hyaenodontids. In fact, the morphology of the tarsus, now nearly completely documented from *W. dioctes*, shows a striking similarity to contemporary hyaenodontids.

Addition of *Wyolestes* to a phylogenetic analysis that broadly samples living and extinct eutherian mammals recovers the genus close to Hyaenodontidae and extant carnivorans. There is no support for a relationship to either Didymoconidae or Mesonychia, nor are those groups closely related to each other.

Technical Session 3: Marine Reptiles (Wednesday, November 2, 2022, 8:00 AM)

A NEW MOSASAURINE FROM THE PIERRE FORMATION (PEMBINA MEMBER: CAMPANIAN) OF NORTH DAKOTA

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Mosasaurians were large, carnivorous aquatic lizards with a global distribution that lived during the Late Cretaceous. After two hundred years of scientific study, mosasaur species continue to be discovered as new localities are explored and specimens collected long ago are re-evaluated using modern methods of species delimitation. Even so, the phylogenetic placements of many key taxa are unresolved and therefore our understanding of mosasaur macroevolution is muddled.

Here, we describe a new genus and species of mosasaurine mosasaur represented by a partial skull (NDGS 10838) and skeleton (NDGS 1033) from the Pembina Member of the Pierre Formation in Cavalier County, North Dakota. The bone layer is situated between 1.5 and 2 meters above the C1 bentonite bed, just above a distinctive pink bentonite that may be the previously described C2 bed. The lower bound on the age of the specimen is 80.04 ±0.11 Ma, provided by the underlying Q3 bentonite bed.

The total length of the skull is estimated to be between 70 and 80 centimeters, and the total body length between 5 and 7 meters. The skull and jaws are nearly complete, and the skeleton includes one front limb, one hind limb, and most of the pelvis and axial skeleton. The new specimen was scored into an existing phylogenetic matrix of Mosasauridae including 54 other taxa and 136 characters, and analyzed using a new technology search. It was recovered in a polytomy with *Dallasaurus* and basal to all other mosasaurines; therefore, we refer it to a new genus and species.

The new specimen is referable to Mosasaurinae based on a groove present in the quadrate tympanic ala, supraorbital process, tall coronoid buttress, and a proximodistally shortened humerus. It is distinguished from other mosasaurines by an edentulous rostrum that is blunt, and from all other known mosasaurids by a humerus that is markedly (i.e., 20%) longer than the femur, a quadrate stapedial pit set within a sulcus, and both maxillae and dentaries that are notably wider than the tooth bases. Notably, this new taxon shares a mosaic of features seen in both basal (e.g., *Clidastes*; high pterygoid tooth count) and derived (e.g., *Mosasaurus*; hourglass-shaped phalanges) mosasaurines. This, in addition to its placement at the base of Mosasaurinae, suggests that it belongs to a lineage of mosasaurines that has thus far been otherwise unrepresented in the fossil record and increases diversity of mosasaurs known from the Pierre Formation.

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Regular Poster Session 3 (Friday, November 4, 2022, 4:30 - 6:30 PM)

BARNACLE ATTACHMENT SCARS ON THE BONES OF LOGGERHEAD SEA TURTLES (*CARETTA*)

CARETTA), CUMBERLAND ISLAND, GEORGIA: IMPLICATIONS FOR THE PALEOECOLOGICAL, AND TAPHONOMIC ANALYSES OF FOSSIL SEA TURTLES

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Sea turtles are characterized by a wide variety of invertebrate ectoparasites. Few of these ectoparasites leave a permanent indication of their presence on the skeletal remains of their host taxa and thus represent ecological information doomed to be lost in the paleontological record. Some barnacle taxa provide an exception to this, in that they cause the formation of small, subcircular to circular divots, pits, and holes on the skull, mandible, carapace or plastron of sea turtles. Loggerhead Sea Turtle (*Caretta caretta*) skeletons from the southeastern USA were examined to assess the presence, frequency and loci of occurrence of barnacle pits, and to establish which taxa are involved in pit development. Six Types of divots and pits attributed to barnacles are identified in this study. Type I traces are shallow, oval/semi-circular in outline, with smooth, gently sloped bases. Type II traces are deep, hemispherical pits with smooth bases. Type III traces are deep, circular to subcircular pits with flat bases. Type IV traces are deep, circular to subcircular pits with multiple (4-6) small sub-pits on their bases. Type V traces are cylindrical, penetrative holes. Type VI traces comprise shallow ring-shaped grooves on the surface of the bone. These traces are consistent with the ichnotaxa *Karethraichnus lakkos*, *K. fiale* and *Thatchtelithichnus holmani*. Barnacle taxa identified as emplacing non-penetrative divots and pits on *C. caretta* skulls, mandibles and shell bones include *Chelonibia caretta* (Type I), *Platylepas hexastylos* (Types I-IV), *Calyptolepas bjorndalae* (Types I and II), and *Stomatolepas elegans* (Types I and II). Penetrative Type V traces were most likely emplaced by either *Stephanolepas muricata* or *Chelolepas cheloniae*. Type VI traces may reflect the former attachment of balanid or lepadid barnacles. Embedded barnacles were observed in epidermal material associated with Types I through IV traces. Barnacle-related pits, divots, and holes on the outer surface of sea turtle bone provide the only commonly preserved evidence of barnacle interactions with sea turtle hosts. The morphology of these features allows for correlation with different barnacle taxa. Identification of definitive barnacle borings in fossil material provides evidence of the evolution of platylepadid barnacles and the development of their commensal relationship with chelonid turtles.

Funding Sources NSERC