WELCOME TO BRISBANE

G’day!

The Host Committee of the 79th Annual Meeting is delighted to welcome all participants to the Society of Vertebrate Paleontology’s 2019 meeting in Brisbane, Queensland, Australia. The meeting will take place at the Brisbane Convention and Exhibition Centre, ideally located in the unique riverside cultural and lifestyle precinct of South Brisbane.

The 79th meeting will be only the third SVP to be hosted outside of North America, and the first one in the Southern Hemisphere. The meeting is co-hosted by The University of Queensland and the Queensland Museum. Although vertebrate fossils were first recognised in Australia by Europeans in the 1830s, global interest in the continent’s vertebrate fossil record was invigorated in the 1950s and 1960s following the fieldwork and research of American paleo-mammalogist, Dr. Ruben Stirton, and his team of students including Richard Tedford and Michael Woodburne. Interest in Australian vertebrate paleontology grew considerably after that time, culminating in the inaugural Conference on Australasian Vertebrate Evolution, Paleontology, and Systematics, an informal, voluntarily organised biennial meeting first held in Brisbane in 1987. The 79th SVP meeting represents a coming-of-age for Australian vertebrate paleontology.

Brisbane’s location as the capital of Queensland’s premier tourist region presents the ideal opportunity for delegates to enjoy a microcosm of Australia’s iconic experiences. World Heritage-listed rainforests, amazing beaches, islands, wineries, and the internationally famous Australia Zoo – home of the ‘Crocodile Hunter’ – are all easily accessible within an hour of the city. It is even possible to do day trips to the Great Barrier Reef from Brisbane. The Queensland Museum’s geoscience collection, based in the Brisbane suburb of Hendra, is the largest paleontological collection in Australia and one of the largest in the Southern Hemisphere.

2019 represents the first SVP Annual Meeting held on a Gondwanan continent and provides a gateway to the major regions of global paleontological significance including other cities and regional locations around Australia, New Zealand, Antarctica, and Southeast Asia. Queensland in particular is home to:

- The Riversleigh World Heritage Area, considered by Sir David Attenborough as one of the four most important fossil sites on Earth;
- A new and diverse suite of Cretaceous-aged dinosaur sites critical in the understanding of Gondwanan biogeography;
- The earliest known Carboniferous tetrapods in Gondwana;
- The youngest uncontested Australian Pleistocene megafauna site, Neds Gully, just a stone’s throw from Brisbane;
- The earliest known crown-group marsupials along with some of the oldest evidence for echo-locating bats, song birds, and extant genera of frogs; and
- The Chinchilla Fauna, Australia’s most extensive Pliocene vertebrate fossil locality and one that contains the forebears to most modern Australian marsupials.

We invite everyone to attend the Welcome Reception at the Queensland Museum where we will highlight Queensland’s rich heritage in vertebrate paleontology. We hope that you will enjoy all that Brisbane, Queensland, and Australia more broadly has to offer during the 79th Annual Meeting of the Society of Vertebrate Paleontology!

Gilbert Price, SVP 79th Annual Meeting Host Committee Co-Chair
Scott Hocknull, SVP 79th Annual Meeting Host Committee Co-Chair
PRESENTATION POLICIES

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

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

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

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

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

Citing an Abstract in the 2019 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, 2019, <insert page number here>.

SVP CODE OF CONDUCT

The Code of Conduct has been updated for 2019. Please familiarize yourself with this updated version. 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. The full policy is available at http://vertpaleo.org/Annual-Meeting/Code-of-Conduct.aspx.
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 #2019SVP. We look forward to seeing your thoughts and discussion online!
PHOTOGRAPHY AND RECORDING

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.
Please check the SVP APP for the latest schedule

2019 SVP Schedule of Events
All events are held at the Brisbane Convention and Exhibition Centre unless otherwise noted with an **

**Tuesday, October 8**

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:00pm–9:00pm</td>
<td>Special Lecture by Professor Michael Archer</td>
<td><strong>UGHD Auditorium, Advanced Engineering Building, The University of Queensland</strong></td>
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<tr>
<td></td>
<td>Life, Sex, Songs, Scrat and the Sponge: Australia’s Guinness Book of Evolutionary Records</td>
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**Wednesday, October 9**

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
<th>Location</th>
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<tbody>
<tr>
<td>8:00am–12:15pm</td>
<td>Technical Session I: Marine Tetrapods</td>
<td>M1&amp;2</td>
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<td>Technical Session II: Dinosaurs I</td>
<td>M3</td>
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<tr>
<td></td>
<td>Symposium: From Molecules to Macroevolution: Paleobiological Applications of Vertebrate Soft Tissue Preservation</td>
<td>M4</td>
</tr>
<tr>
<td>9:30am–6:15 pm</td>
<td>Exhibit and Poster Viewing Hours</td>
<td>Great Hall 1&amp;2</td>
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<tr>
<td></td>
<td>Colbert Prize Competition Posters (B1–B29)</td>
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<tr>
<td></td>
<td>*Colbert Prize posters will be on display Wednesday through Saturday</td>
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<tr>
<td></td>
<td>Education and Outreach Poster Session (B30–B51)</td>
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<td></td>
<td>*Education and Outreach posters will be on display Wednesday through Saturday</td>
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<tr>
<td></td>
<td>Posters associated with Preparators’ Session (B52–B63)</td>
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<td></td>
<td>*Preparators’ posters will be on display Wednesday through Saturday</td>
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<td></td>
<td>Regular Session Posters (B64-B126)</td>
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<tr>
<td>12:15pm–1:45pm</td>
<td>Diversity in Paleontology</td>
<td>P1</td>
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<tr>
<td>1:45pm–4:15pm</td>
<td>Technical Session III: Mammals I</td>
<td>M1&amp;2</td>
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<td>Technical Session IV: Evolution of the Dentition</td>
<td>M3</td>
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<td></td>
<td>Technical Session V: Cenozoic Birds</td>
<td>M4</td>
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<tr>
<td>4:15pm–6:15pm</td>
<td>Exhibit/Poster Mixer</td>
<td>Great Hall 1&amp;2</td>
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<td></td>
<td>Poster Session I Regular Session Posters, (B64-B126)</td>
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<td>*Poster Session I authors will be present at their posters</td>
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<td></td>
<td>Education and Outreach Poster Session (B30-B51)</td>
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<td></td>
<td>*Authors with odd board numbers will be present at their posters</td>
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<tr>
<td>7:30pm–10:30pm</td>
<td>Welcome Reception</td>
<td><strong>Queensland Museum</strong></td>
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## Thursday, October 10

<table>
<thead>
<tr>
<th>Time</th>
<th>Session/Event</th>
<th>Location</th>
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<tbody>
<tr>
<td>8:00am–12:15pm</td>
<td>Technical Session VI: Mammals II</td>
<td>M1&amp;2</td>
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<td>Technical Session VII: Archosaurs</td>
<td>M3</td>
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<td>Romer Prize Session</td>
<td>M4</td>
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<tr>
<td>9:30am–6:15pm</td>
<td><strong>Exhibit and Poster Viewing Hours</strong></td>
<td>Great Hall 1&amp;2</td>
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<td>Colbert Prize Competition Posters (B1–B29)</td>
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<td>*Colbert Prize posters will be on display Wednesday through Saturday</td>
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<td>Education and Outreach Poster Session (B30–B51)</td>
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<td>*Education and Outreach posters will be on display Wednesday through Saturday</td>
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<td></td>
<td>Posters associated with Preparators’ Session (B52–B63)</td>
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<td>*Preparators’ posters will be on display Wednesday through Saturday</td>
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<tr>
<td></td>
<td>Regular Session Posters (B64–B126)</td>
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<tr>
<td>12:30pm–1:30pm</td>
<td>SVP Business Meeting and Open Forum</td>
<td>M4</td>
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<td></td>
<td>An opportunity to bring your questions to SVP leadership!</td>
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<tr>
<td>1:45pm–4:15pm</td>
<td>Technical Session VIII: Mammal Cranial Evolution</td>
<td>M3</td>
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<td>Preparators’ Session</td>
<td>M1&amp;2</td>
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<td></td>
<td>Technical Session IX: Squamates and Herpetofaunas</td>
<td>M4</td>
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<tr>
<td>4:15pm–6:15pm</td>
<td><strong>Exhibit/Poster Mixer</strong></td>
<td>Great Hall 1&amp;2</td>
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<td></td>
<td>Colbert Prize Competition Posters (B1–B29)</td>
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<td></td>
<td>*Authors will be present at their posters</td>
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<td>Posters associated with Preparators’ Session (B52–B63)</td>
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<td>*Authors will be present at their posters</td>
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<td></td>
<td>Poster Session II Regular Session Posters, (B64–B125)</td>
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<td>*Poster Session II authors will be present at their posters</td>
<td></td>
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<tr>
<td>7:30pm–11:30pm</td>
<td><strong>Student and Postdoc Roundtable and Reprint Exchange</strong></td>
<td>M3</td>
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### Friday, October 11

<table>
<thead>
<tr>
<th>Time</th>
<th>Session/Session Details</th>
<th>Location</th>
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<tbody>
<tr>
<td><strong>8:00am–12:15pm</strong></td>
<td>Technical Session X: Fish</td>
<td>M1&amp;2</td>
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<td>Technical Session XI: Mammalian Paleoecology and Macroevolution</td>
<td>M3</td>
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<td>Technical Session XII: Dinosaurs II</td>
<td>M4</td>
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<tr>
<td><strong>9:30am–6:15pm</strong></td>
<td>Exhibit and Poster Viewing Hours</td>
<td>Great Hall 1&amp;2</td>
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<td></td>
<td>Colbert Prize Competition Posters (B1–B29)</td>
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<td><em>Colbert Prize posters will be on display Wednesday through Saturday</em></td>
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<td>Education and Outreach Poster Session (B30–B51)</td>
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<td>Posters associated with Preparators’ Session (B52–B63)</td>
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<td><em>Preparators’ posters will be on display Wednesday through Saturday</em></td>
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<td></td>
<td>Regular Session Posters (B64-B126)</td>
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<tr>
<td><strong>1:45pm–4:15pm</strong></td>
<td>Technical Session XIII: Early Reptiles</td>
<td>M1&amp;2</td>
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<td>Symposium: Quaternary Extinctions in the Asia-Pacific: Causes and Consequences</td>
<td>M3</td>
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<tr>
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<td>Technical Session XIV: Bird Origin and Evolution</td>
<td>M4</td>
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<tr>
<td><strong>4:15pm–6:15pm</strong></td>
<td>Exhibit/Poster Mixer</td>
<td>Great Hall 1&amp;2</td>
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<tr>
<td></td>
<td>Poster Session III Regular Session Posters, (B64-125)</td>
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<td><em>Poster Session III authors will be present at their posters</em></td>
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<td>Education and Outreach Poster Session (B30–B51)</td>
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<td><em>Authors with even board numbers will be present at their posters</em></td>
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<tr>
<td><strong>6:30pm–11:30pm</strong></td>
<td>Annual Benefit Auction and Social</td>
<td>Great Hall 3</td>
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<table>
<thead>
<tr>
<th>Time</th>
<th>Session/Event</th>
<th>Location</th>
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<tbody>
<tr>
<td>8:00am–12:15pm</td>
<td>Technical Session XV: Fins to Limbs</td>
<td>M1&amp;2</td>
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<td>Symposium: Origin of a Sunburnt Country: Development of the Modern Australian</td>
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<td>Vertebrate Fauna from the Late Miocene Onwards</td>
<td>M3</td>
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<td></td>
<td>Technical Session XVI: Dinosaurs III</td>
<td>M4</td>
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<tr>
<td>9:30am–6:15pm</td>
<td>Exhibit and Poster Viewing Hours</td>
<td>Great Hall 1&amp;2</td>
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<td>Colbert Prize Competition Posters (B1–B29)</td>
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<td>*Education and Outreach posters will be on display Wednesday through Saturday</td>
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<td>Posters associated with Preparators’ Session (B52–B63)</td>
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<td>*Preparators’ posters will be on display Wednesday through Saturday</td>
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<td></td>
<td>Regular Session Posters (B64-B126)</td>
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<tr>
<td>1:45pm–4:15pm</td>
<td>Technical Session XVII: Mesozoic and Early Paleogene Mammals</td>
<td>M1&amp;2</td>
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<td>Technical Session XVIII: Evolutionary and Faunal Studies</td>
<td>M3</td>
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<tr>
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<td>Technical Session XIX: Terrestrial and Locomotor Biomechanics</td>
<td>M4</td>
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<td>4:15pm–6:15pm</td>
<td>Exhibit/Poster Mixer</td>
<td>Great Hall 1&amp;2</td>
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<td>Poster Session IV Regular Session Posters, (B64-124)</td>
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<td>*Poster Session IV authors will be present at their posters</td>
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<tr>
<td>7:30pm–10:00pm</td>
<td>Awards Banquet</td>
<td>Plaza Ballroom</td>
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<td>*Ticket required for admittance</td>
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<tr>
<td>10:30pm–12:00am</td>
<td>After Hours Party</td>
<td>Plaza Ballroom</td>
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### 2019 SVP Workshops

*For Pre-registered Attendees*

<table>
<thead>
<tr>
<th>Date/Time</th>
<th>Title</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>TUE, October 8</td>
<td>Women in Paleontology: A Discussion on Promoting Gender Equality</td>
<td>Brisbane Convention and Exhibition Centre</td>
</tr>
<tr>
<td>1:00pm–5:00pm</td>
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<tr>
<td>TUE, October 8</td>
<td>SVP 3D Workshop</td>
<td>The Edge @ State Library of Queensland</td>
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<tr>
<td>9:00am-12:00pm</td>
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<tr>
<td>TUE, October 8</td>
<td>Best Practices in Paleontology: Fossil Laws, Global Perspectives, and</td>
<td>Brisbane Convention and Exhibition Centre</td>
</tr>
<tr>
<td>10:00am-4:00pm</td>
<td>50 Years of UNESCO 1970</td>
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<tr>
<td>TUE, October 8</td>
<td>Neotoma Paleoeconomy Database: Facilitating Transparent Data Curation</td>
<td>Brisbane Convention and Exhibition Centre</td>
</tr>
<tr>
<td>9:00pm-4:30pm</td>
<td>in Vertebrate Paleontology</td>
<td></td>
</tr>
<tr>
<td>TUE, October 8</td>
<td>Australasian Paleontology on the World Stage: CAVEPS 2019</td>
<td>Brisbane Convention and Exhibition Centre</td>
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<tr>
<td>9:00am-4:00pm</td>
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<tr>
<td>TUE, October 8</td>
<td>Fossil Preparation, Conservation, Replication and Storage Techniques</td>
<td>Queensland Museum, Hendra Campus</td>
</tr>
<tr>
<td>9:00am-4:30pm</td>
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<tr>
<td>TUE, October 8</td>
<td>Developing Accessible and Inclusive Research-Focused Paleontology</td>
<td>Brisbane Convention and Exhibition Centre</td>
</tr>
<tr>
<td>9:00am-5:00pm</td>
<td>Education Plans for K-12 Classrooms</td>
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</tbody>
</table>

### 2019 SVP Field Trips

*For Pre-registered Attendees*

For field trip pickup and dropoff locations and times, please check with your field trip leader, check the mobile app, or go to www.vertpaleo.org/Annual-Meeting/Field-Trips.aspx

<table>
<thead>
<tr>
<th>Date/Time</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MON, September 30 – SUN, October 6</td>
<td>Exploring the Cretaceous of Central Queensland, Australia: Dinosaur Tracks, Bones, and Marine Fossils</td>
</tr>
<tr>
<td>FRI, October 4 – TUES, October 8</td>
<td>Rocks and Bones from the Red Centre</td>
</tr>
<tr>
<td>SAT, October 5 – MON, October 7</td>
<td>Australia’s Prehistoric Serengeti: Plio-Pleistocene Megafauna of the Darling Downs</td>
</tr>
<tr>
<td>MON, October 7</td>
<td>Rocks and Fossils of Greater Brisbane</td>
</tr>
<tr>
<td>MON, October 14 – FRI, October 18</td>
<td>Field Trip to Heron Island, Southern Great Barrier Reef</td>
</tr>
<tr>
<td>MON, October 14 – FRI, October 18</td>
<td>Walking with Dinosaurs and Swimming with Placoderms in the Kimberley: Dinosaurian Tracks of the Broome Sandstone and the Upper Devonian Gogo Fish Fauna</td>
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<tr>
<td>MON, October 14 – THU, October 17</td>
<td>The World Heritage Fossil Deposits of Riversleigh, Queensland</td>
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<td>Time</td>
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<tr>
<td>8:00 am</td>
<td>WANG</td>
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<td>8:15 am</td>
<td>HAYASHI</td>
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<td>8:30 am</td>
<td>WINTRICH</td>
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<td>8:45 am</td>
<td>LAMBERT</td>
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<tr>
<td>9:00 am</td>
<td>PARK</td>
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<td>9:15 am</td>
<td>J. SMITH</td>
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<tr>
<td>9:30 am</td>
<td>COSTE</td>
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<tr>
<td>9:45 am</td>
<td>FORDYCE</td>
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<td>10:00 am</td>
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Oscar Sanisidro

Lanzendorf PaleoArt Prize Scientific Illustration  
April Neander

Lanzendorf PaleoArt Prize Sculpture  
Tim Quady

Lanzendorf PaleoArt Prize for National Geographic Digital Modeling and Animation  
Joseph Groenke

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Nadia Rasolofomanana

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Luke Weaver

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Kaleb Sellers

Patterson Student Fieldwork Grant  
Camilo Lopez-Aguirre

Wood Student Research Award  
Bian Wang

Taylor & Francis Award for Best Student Article in JVP - First Place  
Morgan L. Guignard

Taylor & Francis Award for Best Student Article in JVP - Second Place  
Tao Yang

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Ben Kligman  
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List of Authors and Abstract Titles in Chronological Session Order

WEDNESDAY MORNING, OCTOBER 9, 2019
SYMPOSIUM: FROM MOLECULES TO MACROEVOLUTION: PALEOBIOLOGICAL APPLICATIONS OF VERTEBRATE SOFT TISSUE PRESERVATION
MEETING ROOM M4
MODERATORS: Jasmina Weisman and Derek Briggs

8:00 D. E. Briggs, J. Wiemann TRENDS IN SOFT TISSUE PRESERVATION AND ITS ROLE IN REVEALING THE HISTORY OF LIFE
8:15 J. Wiemann, D. E. Briggs FOSSIL SOFT TISSUES RESOLVE THE VERTEBRATE TREE OF LIFE AND RECORD METABOLIC RATES
8:45 K. Trinajstic, J. A. Long, S. Sanchez, C. A. Boisvert, D. Snitting, P. Tafforeau, V. Dupret, P. Currie, B. Roelofs, P. E. Ahlberg EXCEPTIONAL 3D PRESERVATION OF SOFT TISSUES AND ORGANS IN THE VERTEBRATE FAUNA FROM THE LATE DEVONIAN GOGO FORMATION
9:00 E. Tschopp, J. Wiemann, F. Dela Pierre, S. Cavagna, M. A. Norell HOWE QUARRY (UPPER JURASSIC MORRISON FORMATION, WESTERN USA), A HOT SPOT FOR SAUROPOD SOFT TISSUE
9:45 J. A. Clarke, C. Eliason METABOLIC PHYSIOLOGY EXPLAINS MACROEVOLUTIONARY TRENDS IN THE MELANIC COLOUR SYSTEM ACROSS AMNIOTES
10:30 A. Roy, M. Pittman, E. T. Saitta, T. G. Kaye FOSSIL COLOR RECONSTRUCTION IN DINOSAURS AND CLOSE RELATIVES
10:45 A. Hassler, J. E. Martin, R. Amiot, T. Tacail, F. Arnaud-Godet, R. Allain, V. Balter CALCIUM ISOTOPES AND DINOSAUR RESOURCE PARTITIONING
11:00 J. O’Connor, A. Bailleul, M. Wang, Z. Li, Z. Zhou INVESTIGATING PROBABLE REPRODUCTIVE TISSUES IN STEM BIRDS USING ADVANCED MICROSCOPIC ANALYTICAL METHODS
11:30 K. Chin THE COMPLEX TAPHONOMIC HISTORY OF ORGANIC TISSUES WITHIN LITHIFIED COPROLITES
11:45 C. Nedza, M. Purnell, J. Vinther, S. Gabrott DECAY CHANGES THE DISTRIBUTION AND SHAPE OF MELANOSOMES IN AQUATIC VERTEBRATES: IMPLICATIONS FOR THE INTERPRETATION OF COLOUR PATTERNS IN FOSSIL TAXA

WEDNESDAY MORNING, OCTOBER 9, 2019
TECHNICAL SESSION I: MARINE TETRAPODS
MEETING ROOM M1&2
MODERATORS: Carolina Loch and Erich Fitzgerald

8:00 W. Wang, C. Li, X. Wu NEW COMPLETE SKELETON OF PSEPHOCHELYS POLYOSTEODERMA (SAUROPTERYGIA, PLACODONTIA) WITH A DEVELOPING CARAPACE
8:15 S. Hayashi, Y. Nakajima, T. Sato, A. Houssaye, T. Wintrich, Y. Hikida, P. M. Sander MICROANATOMICAL SHIFT IN PLESIOSAUR VERTEBRA: EVOLUTIONARY AND ECOLOGICAL SIGNIFICANCE
8:30 T. Wintrich, C. Fleischle, P. Sander INFERENCE OF PLESIOSAURIAN METABOLIC RATE AND VASCULAR SYSTEM FROM NUTRIENT FORAMINA IN LONG BONES
EARLY DISPERSAL FOR QUADRUPEDAL CETACEANS: AN AMPHIBIOUS WHALE FROM THE MIDDLE EOCENE OF THE SOUTHEASTERN PACIFIC

EXAMINING THE EVOLUTION OF ECHolocation IN ODONTOCETES (MAMMALIA, CETACEA) VIA MORPHOLOGICAL DISPparity OF THE COCHLEA

ENDOCRANIAL MORPHOLOGY AND ENCEPHALIZATION IN THE PROTOCETID CETACEAN GEORGIACETUS VOGTLENSIS

DAUNTING DENTITIONS: TUSKS AND TEETH IN THREE OLIGOCENE DOLPHINS FROM NEW ZEALAND

A ZIPHIID-LIKE PLATANISTOID DOLPHIN FROM THE OTEKAIKE LIMESTONE (WAITAKIAN STAGE, LATEST OLIGOCENE), HAKATARAMEA VALLEY, NEW ZEALAND

NEW MIOCENE SHARK-TOOTHED DOLPHINS FROM AUSTRALIA SHED LIGHT ON THE PHYLOGENY AND BIOGEOGRAPHY OF SQUALODONTIDAE (CETACEA, ODONTOCETI)

BUT DID IT EAT OTHER WHALES? NEW ENAMEL MICROSTRUCTURE AND ISOTOPIC DATA ON LIVYATAN, A LARGE PHYSETEROID FROM THE ATACAMA REGION, NORTHERN CHILE

MIocene Baleen whales FROM the Peruvian desert

NEW DATA ON THE NEogene MARINE MAMMAL FAUNAS OF the Eastern North pacific

FIRST KNOWN MYSTICETE FROM THE FAIRHAVEN MEMBER OF THE CALVERT FORMATION

THE OLDEST KNOWN PACIFIC SIRENIAN FROM THE EARLIEST OLIGOCENE, SAIKAI, NAGASAKI PREFERENCE, WESTERN JAPAN

THE EVOLUTION OF SEALS (FAMILY PHOCIDAE) IN THE SOUTHERN OCEAN: NEW FOSSIL EVIDENCE FROM NEW ZEALAND

NEW WALRUSES FROM THE PURISIMA FORMATION REVEAL PATTERN OF HIGH LOCAL PINNIPED DIVERSITY IN THE MIO–PLIOCENE EASTERN PACIFIC

NEW HIGH-PRECISION U–PB GEOCHRONOLOGY FOR THE WAHWEAP FORMATION, SOUTHERN UTAH AND IMPLICATIONS FOR LATE CRETACEOUS DINOSAUR EVOLUTION IN NORTH AMERICA

WHAT IS AND CAN BE KNOWN ABOUT THE WINTON FORMATION? UNDERSTANDING THE GEOLOGY OF THE WINTON FORMATION AND INTEGRATING NEWLY DISCOVERED FOSSIL FIELDS FROM SOUTH-WEST QUEENSLAND, AUSTRALIA

PALEOENVIRONMENTAL ASSOCIATIONS AND VERTEBRATE ICHNOLOGY OF A DIVERSE, MULTI-LAYERED, DINOSAUR TRACK ASSEMBLAGE FROM THE UPPER CRETACEOUS CANTWELL FORMATION (MAASTRICHTIAN), DENALI NATIONAL PARK AND PRESERVE, ALASKA

A HIGH-LATITUDE ORNITHOPOD AND THEROPOD ICHNOFAUNA FROM THE LATE CRETACEOUS WAPITI FORMATION OF ALBERTA, CANADA

CT IMAGING OF DINOSAUR FOOTPRINTS: HIDDEN TOPOGRAPHY AND THE ORIGIN OF PENETRATIVE TRACK DIVERSITY

A HIGH-LATITUDE ORNITHOPOD AND THEROPOD ICHNOFAUNA FROM THE LATE CRETACEOUS WAPITI FORMATION OF ALBERTA, CANADA

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NEW SAUROPOD DINOSAUR DISCOVERIES IN THE LOWER UPPER CRETACEOUS WINTON FORMATION (CENOMANIAN–LOWER TURONIAN) OF QUEENSLAND, AUSTRALIA: IMPLICATIONS FOR TITANOSAURIAN EVOLUTION

DWARFS AMONG GIANTS: RESOLVING THE SYSTEMATICS OF THE TITANOSAURIAN SAUROPOD DINOSAURS FROM THE LATEST CRETACEOUS OF ROMANIA
9:45  E. Gorscak, J. Sertich, F. K. Manthi  TITANOSAURIAN SAUROPOD DINOSAUR FOSSILS FROM THE UPPER CRETACEOUS LAPUR SANDSTONE (TURKANA GRITS), TURKANA BASIN, NORTHWESTERN KENYA

10:15  H. M. Avrahami, P. Makovicky, L. Zanno  PALEOHISTOLOGY OF A NEW ORODROMINE FROM THE UPPER CRETACEOUS (CENOMANIAN) MUSSENTUCHIT MEMBER OF THE CEDAR MOUNTAIN FORMATION, UTAH: HISTOLOGICAL IMPLICATIONS FOR BURROWING BEHAVIOR

10:30  J. L. Kitchener, N. E. Campione, E. Smith, P. Bell  HIGH-LATITUDE NEONATE AND PERINATE ORNITHOPODS FROM THE MID-CRETACEOUS OF SOUTHWESTERN AUSTRALIA

10:45  R. J. Duncan, S. F. Poropat, T. H. Rich  DESCRIPTION OF FIRST NEORNITHISCHIAN DINOSAUR CRANIAL MATERIAL FROM THE ERIC THE RED WEST LOCALITY (EUMERALLA FORMATION: UPPER APTIAN–LOWER ALBIAN), CAPE OTWAY, VICTORIA, AUSTRALIA


11:45  C. Yu  DIFFERENT DEVELOPMENTAL TRAJECTORIES IN TWO GROUPS OF ORNITHISCHIAN DINOSAURS, HADROSUARIDS AND CERATOPSIDS, REVEALED BY DEEP LEARNING

12:00  C. T. Gee, M. M. Howell, C. Böttger, K. Südekum  A SUPERFOOD FOR MESOZOIC HERBIVORES? EMERGING DATA ON THE EXTREME DIGESTIBILITY OF EQUISETUM AND IMPLICATIONS FOR YOUNG, GROWING HERBIVOROUS SAUROPODS

WEDNESDAY AFTERNOON, OCTOBER 9, 2019
TECHNICAL SESSION III: MAMMALS I
MEETING ROOM M1&2
MODERATOR: Anneke van Heteren

1:45  A. E. Kort  AN EARLY 'CAT GAP'? AN EVALUATION OF OXYAENIDS AS ECOLOGICAL ANALOGUES OF FELIDS


2:15  N. M. Warburton, A. Yates  FUNCTIONAL MORPHOLOGY OF WAKALEO POSTCRANIA FROM THE MIDDLE TO LATE MIocene OF CENTRAL AUSTRALIA REVEALS NEW INSIGHTS IN THE EVOLUTION OF MARSUPIAL HYPERCARNIVORES

2:30  B. F. Kuhn, M. J. Salesa, M. Anton, A. Argant, L. Kgasi, D. Gommery  BURIED PRIDE: MULTIPLE PANTHERA INDIVIDUALS RECOVERED FROM SINGLE FOSSIL DEPOSIT, BOLT'S FARM, SOUTH AFRICA


3:00  A. Hartstone-Rose, E. Elminowski, D. Flores, E. Lindsey, B. Fuller, L. R. Desantis  THE SOUNDS OF RAND COYOTE SITE (RANCHO LA BREA)

3:15  A. H. Van Heteren, B. Figueirido  DIET RECONSTRUCTION IN CAVE BEARS FROM MANDIBULAR MORPHOLOGY

3:30  B. Wang, M. Zelditch, C. Badgley  JAW DISPARITY IN RELATION TO DIET IN THE ARTIODACTyla, WITH IMPLICATIONS FOR PALEOECOLOGY

3:45  P. Medina, K. Moreno  ON THE FORM, MOVEMENT RANGE, AND FUNCTION: CONSTRUCTING A MORPHOFUNCTIONAL SPACE FOR THE EXCAVATION MOTOR GESTURE FOR THE FORELIMB OF CARAGUATIPOTHERIUM MUNOZI (NOTOUNGULATA, MESOTHERIIDAE)

4:00  C. Cleveland, M. Patzkowsky, R. Graham  OREODONT ADAPTATION AND EXTINCTION IN THE CENTRAL HIGH PLAINS, MIOCENE NORTH AMERICA
WEDNESDAY AFTERNOON, OCTOBER 9, 2019
TECHNICAL SESSION IV: EVOLUTION OF THE DENTITION
MEETING ROOM M3
MODERATORS: Kelsey Stilson and Matthew McCurry


2:00 M. R. McCurry, A. R. Evans, E. M. Fitzgerald, C. R. McHenry, J. Bevitt, N. D. Pyenson THE REPEATED EVOLUTION OF APICOBASAL RIDGES IN AQUATIC-FEEDING AMNIOTES


2:30 K. Brink, J. Richman TOOTH REPLACEMENT RATES IN HETERODONT REPTILES

2:45 Y. Wu, L. M. Chiappe, D. J. Bottjer, W. Nava, A. G. Martinelli DENTAL MORPHOLOGY AND REPLACEMENT PATTERN OF LATE CRETACEOUS BRAZILIAN ENANTIOUITHINE BIRDS

3:00 K. T. Stilson, C. F. Ross, Z. Luo, D. A. Reed IMMUNOHISTOCHEMICAL INSIGHTS INTO DISTRIBUTION AND OSTEOLOGICAL CORRELATES OF PERIODONTAL LIGAMENT INNERVATION IN DIDELPHIS VIRGINIANA

3:15 M. W. Colbert, C. T. Griffin SAMPLE SIZE ARTIFACTS IN PALEONTOLOGICAL ANALYSES OF ONTOGENETIC SEQUENCES

3:30 K. R. Selig, W. Khalid, M. T. SileoX COMPLEXITY OF THE LOWER MOLAR ROW IS EXPLAINED BY THE INHIBITORY CASCADE MODEL AND DIET WITHIN EUARCHONTA

3:45 Q. Nasrullah, A. R. Evans TOOTH COMPLEXITY BLUEPRINT AND THE EVOLUTION OF THE ANTEROCONID IN RODENTS

4:00 A. R. Evans, T. I. Pollock, S. G. Cleuren, W. M. Parker, H. L. Richards, T. E. Wilson, D. P. Hocking, J. W. Adams A UNIVERSAL POWER LAW FOR THE GROWTH AND FORM OF TEETH, CLAWS, HORMS, THORNS, AND BEAKS

WEDNESDAY AFTERNOON, OCTOBER 9, 2019
TECHNICAL SESSION V: CENOZOIC BIRDS
MEETING ROOM M4
MODERATORS: Thomas Stidham and Anusuya Chinsamy-Turan

1:45 A. Chinsamy-Turan, T. H. Worthy, W. D. Handley GROWTH STRATEGIES LINKED TO PREVAILING ENVIRONMENTAL CONDITIONS IN AUSTRALIAN GIANT FLIGHTLESS MIHIRUNG BIRDS (AVES: DROMORHITHIDAE)

2:00 A. Chen, N. D. White, R. Benson, M. J. Braun, D. Field TOTAL-EVIDENCE FRAMEWORK REVEALS COMPLEX MORPHOLOGICAL EVOLUTION AND RAPID EVOLUTION IN NIGHTBIRDS (STRISORES)

2:15 D. J. Field, E. E. Sauer CLIMATIC SHIFTS DROVE MAJOR CONTRACTIONS IN AVIAN LATITUDINAL DISTRIBUTIONS THROUGHOUT THE CENOZOIC

2:30 P. Scofield, V. De Pietri, A. Mannering, L. Love, G. Mayr MEDICAL CT REVEALS THE OLDEST, SMALLEST, AND PHYLOGENETICALLY MOST BASAL PELOGERNITHID (AVES: ODONTOPTERYGIFORMES), FROM THE EARLY PALEOCENE OF NEW ZEALAND.

2:45 R. D. Marek THE SURROGATE ARM: FUNCTIONAL AND ECOLOGICAL DRIVERS OF NECK MORPHOLOGY IN EXTANT AVES

3:00 S. Giovanardi, D. T. Ksepka, D. B. Thomas A NEW PHENICIFORM FOSSIL FROM THE NORTH ISLAND OF NEW ZEALAND FURTHER RESOLVES THE BAUPLAN OF EXTINCT GIANT PENGUINS

3:15 K. A. Matts, R. E. Fordyce A NEW LOOK AT THE LATE OLIGOCENE PLATYDIPITES PENGUINS OF ZEALANDIA

3:30 T. Stidham, Z. Li AVIAN EVOLUTION NEAR THE TIBETAN PLATEAU AND EVIDENCE FOR CENTRAL ASIAN ARIDITY IN THE LATE MIocene BASED ON THE FIRST FOSSIL SKELETON OF A SANDGROUSE (AVES: PTEROCLIDAE) FROM THE LIXIA BASIN IN WESTERN CHINA

3:45 N. Smith, J. Watkins, J. Jay PHYLOGENETIC RELATIONSHIPS OF SULIDAE (AVES: SULIFORMES) INFERRED FROM EXTERNAL MORPHOLOGICAL CHARACTERS AND CONGRUENCE BETWEEN MORPHOLOGICAL AND MOLECULAR DATASETS

4:00 N. J. Rawlence EXTINCT BIRDS OF NEW ZEALAND: HOW ANCIENT DNA AND MORPHOLOGY IS RAPIDLY INCREASING THE NUMBER OF HUMAN DRIVEN EXTINCTIONS
**WEDNESDAY - SATURDAY, OCTOBER 9-12, 2019**  
**COLBERT PRIZE POSTER SESSION**  
**GREAT HALL 1&2**  
Authors must be present from 4:15 - 6:15 p.m. Thursday, October 10

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EDUCATION AND OUTREACH POSTER SESSION

GREAT HALL 1&2

Authors with odd-numbered boards must be present from 4:15 - 6:15 p.m. Wednesday, October 9

Authors with even-numbered boards must be present from 4:15 - 6:15 p.m. Friday, October 11
B43  G. Santos, L. Lundgren, M. Barboza-Ramirez, M. J. Ziegler, B. Stoneburg  COSPLAY FOR SCIENCE: UTILIZING POP CULTURE NARRATIVES AS A MEANS FOR SCIENCE EDUCATION OUTSIDE TRADITIONAL LEARNING CENTERS

B44  S. M. Rutzky  FUNDING MEANINGFUL RESEARCH EXPERIENCES ENCOURAGES UNDERGRADUATES TO PURSUE DEGREES IN PALEONTOLOGY AND GEOSCIENCE

B45  L. D. White, D. C. Pagnac, G. Bowser  FIELDWORK INSPIRING EXPANDED LEADERSHIP AND DIVERSITY (FIELD): OVERCOMING BARRIERS TO FIELDWORK IN PALEONTOLOGY

B46  A. W. Kellner, J. M. Sayão  THE PALEOANTAR PROJECT—COMBINATION OF SCIENCE, EDUCATION AND OUTREACH FOCUSING ON ANTARCTICA

B47  S. S. Sumida, S. Walker  THE PATTERNS PROJECT—PHYLOGENY-DRIVEN, ANATOMICAL TAXON TRANSFORMATION AS EDUCATION RESOURCE FOR NATURAL SCIENCES: USING DIGITAL MORPHING ANIMATION TO INTERPOLATE STRUCTURES AND ENHANCE EDUCATION AND OUTREACH IN VERTEBRATE PALEONTOLOGY

B48  K. Fox-Dobbs, T. Hill, D. Ibarra, J. Oster, P. Workshop Participants  A CALL TO ACTION AFTER THE PALEO TO POLICY WORKSHOP: HOW TO BUILD BRIDGES BETWEEN PALEONTOLOGICAL RESEARCH AND DECISION MAKING

B50  S. Turner, A. Berta  "BONE HUNTERS" PROJECT—AUSTRALASIAN WOMEN IN VERTEBRATE PALEONTOLOGY

B51  S. Hinic-Frlg, R. R. Reisz  USING FOSSIL SCIENTIFIC STORIES AS TOOLS TO ENGAGE STUDENTS WITH SCIENTIFIC LITERACY LEARNING OUTCOMES IN A CORE DEPARTMENTAL CURRICULUM

WEDNESDAY - SATURDAY, OCTOBER 9-12, 2019
PREPARATORS’ SESSION
GREAT HALL 1&2
Authors must be present from 4:15 - 6:15 p.m. Thursday, October 10

B52  T. Sato, A. Shinya  A PRACTICAL GUIDE TO START A NEW VERTEBRATE FOSSIL PREPARATION LAB

B53  A. Shinya, C. J. Van Beek, P. Makovicky  CHALLENGES IN THE FIELD: COLLECTING WET VERTEBRATE FOSSILS WITH THE APPLICATION OF ACRYSOL WS24, ACRYLOID B72, AND CYANOACRYLATE CONSOLIDANTS

B54  D. J. Ward, A. E. Ward  SIEVING WITHOUT TEARS: THE FIRST 40 YEARS OF AUTOMATED SEDIMENT SCREENING FOR MICROVERTEBRATES

B55  M. R. Fair, P. J. May, S. J. Jabo, G. Dallman, A. S. Madill  REMOVING ASBESTOS FROM RECONSTRUCTED AREAS OF SPECIMENS AT THE SMITHSONIAN MUSEUM OF NATURAL HISTORY SAFELY AND WITH THE LEAST IMPACT TO THE SPECIMEN

B56  P. May, D. Evans, A. Madill, M. Fair  UNEARTHING A GIANT: THE MAKING OF ZUUL

B57  J. E. Wilkinson  ACID PREPARATION OF CARBONACEOUS FOSSIL MATERIAL USING A MEDICAL INTRAVENOUS KIT FOR TARGETED DELIVERY OF 7% ACETIC ACID SOLUTION.

B58  S. R. Johnston, A. Davidson  PHOTOGRAPHS AND FOSSIL FILLINGS: A REVERSIBLE POLYESTER FILM AND UTILIZING NATIVE IPHONE APPS FOR COMPREHENSIVE PHOTO DOCUMENTATION

B59  M. Ferrer Ventura, A. Torices, X. Mas I Barberà, R. San Juan Palacios, P. Navarro Lorbiés  THE USE OF TRADITIONAL MORTARS AND HIDROFUGANTS IN RESTORATION AND PRESERVATION OF PALEOICHNOLOGICAL SITES

B60  V. R. Rhue  MANAGEMENT OF COLLECTIONS CARE PROJECTS: REFINING THE APPROACH TO CURATION WORKFLOWS AND PERSONNEL TRAINING

B61  B. A. Lauters  COMPARATIVE ANALYSIS OF PARALOID B-72 AND BUTVAR B-76 DISSOLVED IN ACETONE SOLUTIONS

B62  E. Ghezzo, M. Massironi, E. B. Davis  HIGH RESOLUTION REMOTE SENSING APPLIED TO FOSSIL DISCOVERY: OVERVIEW AND PROSPECTS

B63  R. Aguilar  MILLIONS OF YEARS, DOZENS OF SAMPLES, ONE SINGLE SCAN: NEW METHODS TO RAPIDLY INCREASE THE NUMBER OF SPECIMENS CAPTURED IN A SINGLE HIGH QUALITY SCAN.

A NEW LATE PLEISTOCENE SUBFOSSIL SITE (TSARAMODY, SAMBAINA BASIN, CENTRAL MADAGASCAR) WITH IMPLICATIONS FOR THE CHRONOLOGY OF HABITAT AND MEGAFANAL COMMUNITY CHANGE ON MADAGASCAR'S CENTRAL HIGHLANDS


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THURSDAY MORNING, OCTOBER 10, 2019
ROMER PRIZE SESSION
MEETING ROOM M4
MODERATORS: Kenneth Angielczyk and Julia Clarke

8:00
A. Elsler  HETEROGENEOUS EVOLUTIONARY RATES DURING THE FIRST HALF OF TERRESTRIAL TETRAPOD EVOLUTION

8:15
D. Foffa  DIETARY AND HABITAT PARTITIONING OF JURASSIC MARINE REPTILE ECOSYSTEMS

8:30
M. M. Johnson  WHAT ARE TELEOSAURIDAE AND STENEOSAURUS? THE TAXONOMY, SYSTEMATICS, AND ECOMORPHOLOGICAL DIVERSITY OF TELEOSAUROIDA (CROCODYLOMORPHA, THALATTOSUCHIA)

8:45
A. Krahl  MUSCLE RECONSTRUCTIONS AND HUMERUS AND FEMUR FINITE ELEMENT ANALYSES OF CRYPTOCLIDUS EURYMERUS (PLESIOSAURIA) SUPPORT UNDERWATER FLIGHT AND FLIPPER TWISTING

9:00
G. F. Funston  GROWTH AND BEHAVIOUR IN OVIRAPTOROSAURS

9:15
S. W. Evers  NEW INSIGHTS INTO THE EVOLUTION OF SECONDARILY MARINE LIFESTYLES, MARINE ADAPTATION, AND DIVERSIFICATION OF TURTLES

9:30
D. F. Terrill  STRONTIUM ISOTOPES: A NEW TOOL FOR EXPLORING MIGRATORY BEHAVIOURS IN ORNITHISCHIAN DINOSAURS
THURSDAY MORNING, OCTOBER 10, 2019
TECHNICAL SESSION VI: MAMMALS II
MEETING ROOM M1&2
MODERATORS: Suzanne Cote and Dorien de Vries

8:00  E. H. Reed  FOSSIL RECORD OF THE SOUTHERN BENT-WING BAT (MINIOPTERUS ORIANAE BASSANII) FROM QUATERNARY DEPOSITS AT NARACOTRE CAVES, SOUTH AUSTRALIA: IMPLICATIONS FOR CONSERVATION OF A CRITICALLY ENDANGERED SPECIES

8:15  C. Lopez-Aguirre, A. Link  DENTAL TOPOGRAPHY ANALYSIS AND DIETARY INFERENCE OF THE MIocene NEOTROPICAL BAT NOTONYCTERIS MAGDALENENSIS FROM LA VENTA, COLOMBIA

8:30  J. L. Alumbaugh, K. Samonds, S. M. Goodman, L. Godfrey  A MORPHOMETRIC ASSESSMENT OF MODERN AND EXTINCT MACRONYCTERIS SP. (CHIROPTERA, HIPPOSIDERIDAE) ON MADAGASCAR

8:45  D. De Vries, H. M. Sallam, E. R. Seiffert  DENTAL TOPOGRAPHIC EVOLUTION IN RODENTS ACROSS THE EOCENE–OLIGOCENE BOUNDARY IN THE FAYUM DEPRESSION, EGYPT

9:00  S. S. Hopkins, J. J. Caledo  OLIGO-MIOCENE APLODONTIOD RODENTS REVEAL FAUNAL AND ECOLOGICAL RELATIONSHIPS BETWEEN CENTRAL OREGON AND WESTERN MONTANA


9:30  A. E. Marcy, K. C. Rowe, E. Sherratt, T. Guillerme, M. J. Phillips, V. Weisbecker  INTRINSIC CONSTRAINTS APPEAR TO UNDERLIE STRONG ALLOMETRIC PATTERNS IN AUSTRALIAN RODENT DIVERSITY

9:45  M. M. Lang, G. San Martin Flores, O. Bertrand, L. Nagendran, S. Lopez-Torres, M. T. Silcox  ENDOCRANIAL SHAPE VARIATION WITHIN EUARCHONTOGYRIUSES USING 3D GEOMETRIC MORPHOMETRICS

10:00  S. Cote, K. McNulty, J. Kelley  AN UNUSUAL FOSSIL HOMINOID ASSEMBLAGE FROM TINDERET, KENYA

10:15  D. R. Begun  NAKALIPITHECUS AND HOMININE ORIGINS

10:30  O. Sanisidro Morant, J. López Cantalapiedra, S. Cote  A REVIEW OF AFRICAN ELASMOTHERES (MAMMALIA, RHINOCerotidae) AND THEIR ROLE ON EARLY MIocene MIGRATION EVENTS INTO EAST AFRICA
**THURSDAY MORNING, OCTOBER 10, 2019**

**TECHNICAL SESSION VII: ARCHOSAURS**

**MEETING ROOM M3**

**MODERATORS: Elizabeth Martin-Silverstone and Alan Turner**

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<td>8:15</td>
<td>D. Pol, P. C. Sereno</td>
<td>NEW JURASSIC AND CRETAECOUS NEOCUCANID FROM THE SAHARA ADD TO AFRICA’S REMARKABLE CROCODYLIFORM DIVERSITY AND ITS PALEOGEOGRAPHIC CONNECTIONS WITH NORTHERN LANDMASSES</td>
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<td>8:30</td>
<td>A. H. Turner, A. Watanabe, A. R. Beyl, A. H. D’Amore, E. Wilberg, J. H. Smaers, P. M. Gignac</td>
<td>ECOMORPHOLOGICAL AND ALLOMETRIC SIGNATURES IN ENDOCRANIAL SHAPE IN CROCODYLIANS</td>
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<tr>
<td>8:45</td>
<td>M. A. White, P. Bell, N. E. Campione, G. Sansalone, T. Brougham</td>
<td>A NEW CROCODYLIFORM FROM THE WINTON FORMATION (CA 95 MA) OF QUEENSLAND (AUSTRALIA)</td>
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<tr>
<td>9:00</td>
<td>M. Rubin</td>
<td>A NEW ALLIGATORINE FROM THE MIDDLE EOCENE OF UTAH AND THE ORIGINS OF MODERN ALLIGATOR</td>
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<tr>
<td>9:30</td>
<td>P. C. Sereno, D. Pol</td>
<td>AN AGILE UNARMORED NOTOSUCHIAN FROM CENOMANIAN-AGE ROCKS IN NIGER INITIATE THE PARTITIONING OF THE GONDWANAN PLEXUS OF ARARIPESUCHUS SPECIES</td>
</tr>
<tr>
<td>10:30</td>
<td>J. D. Fortner</td>
<td>PHYTOSAUR TOOTH DENTIN REVEALS NORIAN ARIDIFICATION PROCESSES INFLUENCED THE DIAGENETIC ENVIRONMENT OF THE CHINLE FORMATION</td>
</tr>
<tr>
<td>11:00</td>
<td>M. Qvarnström, E. Elgh, K. Owocki, P. E. Ahlberg, G. Niedźwiedzi</td>
<td>FILTER FEEDING IN LATE JURASSIC PTEROSAURS SUPPORTED BY COPROLITE CONTENTS</td>
</tr>
<tr>
<td>11:30</td>
<td>E. Martin-Silverstone, D. M. Unwin, P. M. Barrett</td>
<td>A NEW, THREE-DIMENSIONALLY PRESERVED MONOFENESTRATAN PTEROSAUR FROM THE MIDDLE JURASSIC OF SCOTLAND AND THE COMPLEX EVOLUTIONARY HISTORY OF THE SCAPULO-VERTEBRAL ARTICULATION</td>
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<tr>
<td>12:00</td>
<td>Y. Zhang, W. Morita, J. Jernvall</td>
<td>TOWARDS AN ADVANCED WEIGHTING APPROACH TO ACCOUNT FOR CHARACTER INTERDEPENDENCIES IN AN ADJUSTED PARSIMONY METHOD, FOR PHYLOGENETIC INFEERENCE USING PHENOTYPIC DATA</td>
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**THURSDAY AFTERNOON, OCTOBER 10, 2019**

**TECHNICAL SESSION VIII: MAMMAL CRANIAL EVOLUTION**

**MEETING ROOM M3**

**MODERATORS: Julia Schultz and Juri Miyamae**

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker(s)</th>
<th>Title</th>
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<tbody>
<tr>
<td>2:00</td>
<td>J. A. Miyamae, B. Bhullar</td>
<td>SENSING OR SUCKLING? THE EVOLUTION OF MAMMALIAN FACIAL MUSCLES</td>
</tr>
<tr>
<td>2:15</td>
<td>J. Meng, F. Mao, Y. Wang, C. Li</td>
<td>EVOLUTION OF THE MAMMALIAN JAW JOINT AND MIDDLE EAR AT THE STAGE OF BASAL THERIANS</td>
</tr>
</tbody>
</table>
THURSDAY AFTERNOON, OCTOBER 10, 2019
TECHNICAL SESSION IX: SQUAMATES AND HERPETOFAUNAS
MEETING ROOM M4

MODERATORS: John Jacisin and Simon Scarpetta

1:45  E. Amson, R. Ebel, J. Mueller  CRANIAL BONE INNER STRUCTURE AND FOSSORIALITY IN LEPIDOSAURIA
2:00  W. Phanratatanamongkol, J. Head  FOSSIL AND EXTANT MORPHOLOGIES REVEAL REPEATED DEVELOPMENT OF DISTAL HIND LIMBS IN THE EVOLUTION OF SNAKES
2:15  A. Bolet, T. L. Stubbs, J. A. Herrera-Flores, M. J. Benton  NEW INSIGHTS ON LEPIDOSAUR EVOLUTION AS INFORMED FROM EVOLUTIONARY RATES AND DISPARITY ANALYSIS
2:30  K. K. Formoso, M. Habib, D. Bottjer  REASSESSING THE MOSASAUR PECTORAL GIRDLE AND ITS ROLE IN SWIMMING FUNCTION: NOT ENTIRELY WHALE-LIKE AFTER ALL
2:45  J. J. Jacisin, A. M. Lawing  SNAKE VERTEBRAL SHAPE AS AN ECOMETRIC METHOD, AND ITS IMPLICATIONS FOR SNAKE DISTRIBUTIONS AT LOCAL TO REGIONAL SCALES.
3:00  S. G. Scarpetta  THE FIRST KNOWN FOSSIL OF UMA DEMONSTRATES EXAPTATION AND ECOLOGICAL EVOLUTION IN A SPECIALIZED CLADE
3:15  M. F. Bonnan, L. M. Crisp, A. Barton, J. Dizinno, K. Muller, J. Smith, J. Walker  EXPLORING ELBOW KINEMATICS OF THE CENTRAL BEARDED DRAGON (POGONA VITTICEPS) USING XROMM: IMPLICATIONS FOR ANCESTRAL AMNIOTE ELBOW FUNCTIONAL MORPHOLOGY
3:30  L. E. Roberts, J. J. Head  ELUCIDATING CRYPTIC AXIAL SKELETAL REGIONALIZATION IN REPTILIA: IMPLICATIONS FOR VERTEBRATE EVOLUTIONARY-DEVELOPMENTAL HISTORY

THURSDAY AFTERNOON, OCTOBER 10, 2019
PREPARATORS’ SESSION
MEETING ROOM M1&2

MODERATORS: Matthew Miller and Vanessa Rhue

1:45  M. T. Miller, A. Millhouse, H. Little  PITFALLS AND SUCCESSES: THE EVOLUTION OF THE NATIONAL MUSEUM OF NATURAL HISTORY (SMITHSONIAN INSTITUTION) PALEOBIOLOGY COLLECTIONS VOLUNTEER CATALOGING PROGRAM
2:00  C. J. Van Beek, A. Shinya  PREPARATION OF WET VERTEBRATE FOSSILS: DEVISING STRATEGIES TO MITIGATE DAMAGE
2:15  J. R. Groenke, P. M. O’Connor, L. Dougan, S. H. Burch, R. R. Rogers  DIGITAL AND MECHANICAL PREPARATION OF DELICATE SKELETAL REMAINS FROM AN UPPER CRETACEOUS BONEBED IN MADAGASCAR
THURSDAY AFTERNOON, OCTOBER 10, 2019
REGULAR POSTER SESSION II
GREAT HALL 1&2
Authors must be present from 4:15 - 6:15 p.m. Thursday, October 10

A NEW LATE PLEISTOCENE SUBFOSSIL SITE (TSARAMODY, SAMBAINA BASIN, CENTRAL MADAGASCAR) WITH IMPLICATIONS FOR THE CHRONOLOGY OF HABITAT AND MEGAFAUNAL COMMUNITY CHANGE ON MADAGASCAR'S CENTRAL HIGHLANDS

B65 R. A. Lawrence, S. Hocknull, J. Cramb
LOST IN SPACE AND TIME: NEW QUATERNARY SMALL VERTEBRATE RECORDS FROM THE FITZROY RIVER BASIN OF TROPICAL QUEENSLAND, AUSTRALIA

B66 C. J. Piper, P. Veth
PALEOECOLOGY AND OCEAN VIEWS: DECLINE OF MAMMAL SPECIES RICHNESS DURING LATE QUATERNARY ISLAND FORMATION IN THE MONTEBELLO ISLANDS, NORTH-WESTERN AUSTRALIA

B67 N. K. Turner, L. H. Reed, L. Arnold
PALEONTOLOGICAL INVESTIGATION OF A MIDDLE PLEISTOCENE VERTEBRATE FOSSIL ASSEMBLAGE FROM SPECIMEN CAVE, NARACOORTE, SOUTH AUSTRALIA

B68 T. L. Bampton, J. Tyler, F. Melinerney, E. Reed
STABLE ISOTOPIC SIGNATURES OF FOSSILISED RODENT TEETH: FAUNAL RESPONSE TO CLIMATE CHANGE IN SOUTH-EASTERN AUSTRALIA DURING THE LATE QUATERNARY

B69 E. A. Parker, L. A. Reed
NARACOORTE CAVES: INTERPRETING THE WORLD HERITAGE OF SOUTH-EASTERN SOUTH AUSTRALIA

B70 P. Kondrashov, A. Agadjanian
SMALL MAMMAL AND MOLLUSC FAUNAS FROM THE MIDDLE PLEISTOCENE OF CENTRAL RUSSIA

THE EARLY PLEISTOCENE TERRESTRIAL VERTEBRATE FAUNAL SEQUENCE OF JAVA, INDONESIA

B72 M. Duval
DIRECT ESR DATING OF THE LATE MIDDLE PLEISTOCENE VERTEBRATE ASSEMBLAGE FROM KHOK SUNG LOCALITY, THAILAND

B73 K. M. Magoullick
THE MAMMAL ASSEMBLAGE OF CRYSTAL CAVERNS AND A COMPARATIVE ANALYSIS OF CALIFORNIA CAVE DEPOSITS

B74 J. Treloar, E. H. Reed
TAPHONOMIC ANALYSIS OF AUSTRALIAN OWL PELLET ASSEMBLAGES AS ANALOGUES FOR QUATERNARY DEPOSITS AT NARACOORTE CAVES, SOUTH AUSTRALIA

GEOLOGICAL AND PALEONTOLOGICAL ASPECTS OF A NEW EARLY–MIDDLE PLEISTOCENE TERRESTRIAL VERTEBRATE FOSSIL-BEARING SITE IN WEST JAVA, INDONESIA

B76 M. J. Powley, G. D. Van Den Bergh, I. Kurniawan, I. Sutisno
TAPHONOMIC CHANGES OF EARLY MIDDLE PLEISTOCENE STEGODON BONE ASSEMBLAGES FROM FLORES, INDONESIA

STABILITY OF DENTAL MESOWEAR SCORES THROUGHOUT THE LATE PLEISTOCENE IN LARGE Ungulates FROM RANCHO LA BREA

B78 S. A. McLeod, J. A. Hook
A PLEISTOCENE VERTEBRATE FAUNA FROM A GROUND SLOTH SITE, GYPSUM CAVE, NEVADA, USA

B79 B. Choo, W. Zhao, X. Cui, L. Jia
AN EXCEPTIONALLY PRESERVED ANTIARCH AND OTHER DISCOVERIES FROM THE EARLY DEVONIAN GUANSHANPO FORMATION, PINGYIPU GROUP, SICHUAN
B80  B. M. Wynd, T. Daeschler, M. R. Stocker  EVOLUTIONARY HOMOLOGY IN THE FIN-TO-LIMB TRANSITION: EVALUATING THE MORPHOLOGY OF FORAMINA IN A LATE DEVONIAN HUMERUS FROM THE CATSKILL FORMATION, CLINTON COUNTY, PENNSYLVANIA


B83  B. R. Preece, A. W. Bronson, B. K. Otoo, C. A. Sidor  FRESHWATER FISH FAUNAS FROM TWO PERMIAN RIFT VALLEYS OF ZAMBIA, WITH BIOGEOGRAPHIC IMPLICATIONS FOR SOUTHERN PANGEA

B84  C. J. Duffin  THE PRE-SCIENTIFIC USES OF FOSSIL SHARKS’ TEETH

B85  G. Fang, F. Wu, Y. Sun, C. Ji  A NEW SPECIES OF SAURICHTHYS (ACTINOPTERYGII, SAURICHTHYIDAE) EXTENDS ITS GROUP’S RANGE TO THE LATE TRIASSIC IN EASTERN TETHYS

B86  R. W. Berrell, L. Cavin  REVISION OF DUGALDIA EMMILTA (TELEOSTEI, ICHTHYODECTIFORMES) FROM THE EARLY CRETACEOUS OF AUSTRALIA.

B87  J. A. Lane, M. Ebert, V. Schwaworoch  A RE-EVALUATION OF 'FURO' MICROLEPIDOTES (NEOPTERYGII, HALECOMORPHI) FROM THE UPPER JURASSIC SOLNHOFEN ARCHIPELAGO OF GERMANY

B88  J. Liu, G. Chen, M. Chang  PROGRESS IN THE STUDY OF PALEogene ichthyofauna from onshore basins around Beibu gulf of China

B89  S. El-Sayed, A. M. Murray, M. Kora, M. Antar, E. Seiffert, H. M. Sallam  NEW PERCOMORPH FISH FROM THE LATE EOCENE QASR EL-SAGHA FORMATION, FAYUM, EGYPT

B90  T. M. Frank, M. A. Bell  DOCUMENTING AN ECOLOGICAL REPLACEMENT EVENT FROM THE MIOCENE ON AN ECOLOGICAL TIMESCALE

B91  H. M. Byrne, H. Blom, G. Niedzwiedzki, B. P. Kear, P. E. Ahlberg  VIRTUAL 3D-RECONSTRUCTION OF INCLUSIONS FROM THREE LARGE COPROLITES FROM AN EARLY TOURNAISIAN LAKE DEPOSIT.

B92  B. K. Otoo, J. R. Bolt, E. Lombard, K. Tietjen, M. I. Coates, K. D. Angielczyk  NEW DIVERSITY IN EARLY TETRAPOD HIND LIMBS


B95  D. Marjanović, M. Laurin, O. Lapauze  WHAT DO OSSIFICATION SEQUENCES TELL US ABOUT THE ORIGIN OF EXTANT AMPHIBIANS?

B96  E. M. Teschner, D. Konietzko-Meier  MYSTERIOUS METOPOSAURIDS: PALEOHISTOLOGY HELPS TO UNDERSTAND INTERSPECIFIC VARIETY AMONG LATE TRIASSIC AMPHIBIANS

B97  A. R. Guillaume, M. Moreno-Azanza, O. Mateus  NEW LISSAMPHIBIAN MATERIAL FROM THE LOURINHÃ FORMATION (LATE JURASSIC, PORTUGAL)

B98  M. Jansen, J. Renaudie, S. Voigt, M. Buchwitz  RECONSTRUCTION OF AN ANCESTRAL AMNIOTE TRACKMAKER BASED ON TRACKWAY DATA, TRACKMAKER CORRELATION AND PHYLOGENY

B99  A. Smith, J. C. Havstad  FOSSILS WITH FEATHERS AND PHILOSOPHY OF SCIENCE

B100  D. P. Rhoda, S. Hellert, P. Polly  SHIFTING PATTERNS OF FUNCTIONAL INTEGRATION DURING THE EVOLUTION OF FLIGHT IN THEROPODS

B101  R. M. Carney, H. Tischlinger, M. D. Shawkey  BIRDS OF A FEATHER: CALAMUS CORROBORATES IDENTITY OF ARCHAEOPTERYX WING COVERT


B103  M. Pérez-Pueyo, E. Puértolas-Pascual, M. Moreno-Azanza, P. Cruzado-Caballerio, J. M. Gasca, J. I. Canudo  ON THE PRESENCE OF A PUTATIVE ORNITHURAE (AVES) IN THE LATE MAASTRICHTIAN VERTEBRATE FAUNAS FROM SOUTHERN PYRENEES (SPAIN)

B104  T. Smith, G. Mayr  PALEOCENE AND EARLY EOCENE BIRD ASSEMBLAGES FROM THE SOUTHERN NORTH SEA BASIN

B105  M. D. Richards, K. A. Matts, R. E. Fordyce  PARAPTENODYTES-LIKE FOSSIL PENGUINS FROM NEW ZEALAND—A BIOGEOGRAPHIC CLUE FROM THE LATE Oligocene?

B106  A. J. Tennyson  FOSSIL BIRD BONES FROM THE SUBANTARCTIC AUCKLAND ISLANDS
DIAGNOSIS OF THE PRINCIPAL TAXA OF TERATORNITHIDAE (AVES: ACCIPITRIFORMES), INCLUDING TERATORNIS MILLER 1909 AND ITS SPECIES T. MERRIAMI AND T. WOODBURNENSI

A NEW SPECIES OF EOGRU RIDAE (AVES, GRUIFORMES) FROM THE MIOCENE OF THE LINXIA BASIN, GANSU, CHINA: EVOLUTIONARY AND CLIMATIC IMPLICATIONS

A BIRD'S-EYE VIEW OF ANCIENT LANDSCAPES AT HAGERMAN FOSSIL BEDS NATIONAL MONUMENT, IDAHO, USA

10 YEARS OF DISCOVERY: REVISITING THE QUALITY OF THE SAUROPODOMORPH FOSSIL RECORD

PALEONEUROANATOMY OF A NEW RIOJASAURID (DINOSAURIA, SAUROPODOMORPHA) FROM THE LATE TRIASSIC OF ARGENTINA

THE BASAL SAUROPODOMORPH THECODONTOSAURUS FROM THE LATE TRIASSIC OF BRITAIN: OSTEOLOGICAL RE-DESCRIPTION, LIMB MUSCULATURE RECONSTRUCTION AND LOCOMOTION

SKELETAL ONTOGENY OF MASSOSPONDYLUS CARINATUS

REFERRED SPECIMEN OF CHUANJIESAURUS ANAENSIS AS A NEW EARLY BRANCHING MAMENCHISAURID SAUROPOD TAXON FROM THE MIDDLE JURASSIC OF CHINA

EXPANDING CETIOSAURID DIVERSITY IN THE MIDDLE JURASSIC

SAUROPOD DINOSAUR TRACKS AND ASSOCIATED SEDIMENTARY STRUCTURES IN THE BROOME SANDSTONE (CRETACEOUS) OF WESTERN AUSTRALIA

TOOTH MORPHOMETRICS CAN DIFFERENTIATE MORRISON FORMATION DIPLODOCIDS

GEOGRAPHICAL SEGREGATION DUE TO ECological COMPETITION AMONG LATE JURASSIC DIPLODOCID SAUROPODS FROM THE MORRISON FORMATION (WESTERN USA)

MORPHOLOGY AND NEUROVASCULAR ANATOMY OF A TITANOSAUR SAUROPOD OSTEODERM FROM THE UPPER CRETACEOUS OF BIG BEND NATIONAL PARK, TEXAS

COMPARATIVE OSTEOLOGY OF ENTOPLASTRA REVEALS THEIR DIAGNOSTIC UTILITY FOR DIFFERENTIATING NORTH AMERICAN HELOCHELYDRID SPECIES

NEW SPECIMENS REVEAL A HIGH ELEVATION, LOW DIVERSITY MIOCENE TESTUDINOID COMMUNITY IN EASTERN IDAHO, USA

EARLY OSTEICHTHYAN EVOLUTION: INSIGHTS FROM NEW DATA OF THE SILURIAN MEGAMASTAX

A NEW SILURIAN BONY FISH CLOSE TO THE COMMON ANCESTOR OF CROWN GNATHOSTOMES

EXCEPTIONALLY WELL-PRESERVED FISHES, INCLUDING A NEW POROLEPIFORM AND NEW ARTHRODIRES, FROM THE LATE DEVONIAN GOGO FORMATION OF WESTERN AUSTRALIA

MACHINE LEARNING BASED EARLY DEVONIAN VERTEBRATE MICROFOSSILS TOMOGRAPHY SEGMENTATION AND RECONSTRUCTION
9:15  E. M. Dowding, M. C. Ebach  DEVONIAN BIOGEOGRAPHY: EVALUATING DATA AND AREAS
9:30  T. Argyriou, C. Romano  NEW FINS OR OLD FINS? SKULL AND PECTORAL GIRDLE OF EARLY TRIASSIC 'PERLEIDUS WOODWARDI' REVISITED USING µCT
9:45  L. B. Bean, G. Arratia  OUTSTANDING MORPHOLOGY OF SOME MESOZOIC GONDWANAN FISH CONFLICTING PREVIOUS TAXONOMIC AND PHYLOGENETIC INTERPRETATIONS.
10:15  J. Liston, A. Heyng  THE BEAST OF MÜHLHEIM: FIRST EVIDENCE OF A SOLNHOFEN MEGAPLANKTIVORE
10:30  T. Daeschler, J. P. Downs, N. Lo, E. N. Carey, N. H. Shubin  ASTEROLEPIS SPP. AND OTHER ANTIARCH PLACODERMS FROM THE FRAM FORMATION (UPPER DEVONIAN, FRASNIAN) OF ELLESMERE ISLAND, NUNAVUT TERRITORY, CANADA
10:45  K. M. Claesson, Z. Jinnah, J. A. Clarke, P. M. O'Connor, M. C. Lamanna  ABUNDANT LIZARDFISHES (AULOPIFORMES, BATHYSARIAE) IN AN EARLIEST PALEOGENE HORIZON IN ANTARCTICA CASTS LIGHT ON THE ORIGIN OF THE ASSEMBLAGE
11:00  J. J. Cawley, G. Marrama, G. Carnevale, J. Kriwet  INVESTIGATION OF THE EVOLUTIONARY SUCCESS AND EXTINCTION OF Pycnodont FISHES USING QUANTITATIVE METHODS
11:15  F. Wu, M. Chang, D. He, G. Fang, T. Deng  PROGRESS IN THE RESEARCH ON THE CENOZOIC FISH FAUNA FROM THE TIBETAN PLATEAU
11:30  M. Bazzi, N. Campione, B. Keir, H. Blom, P. E. Ahlberg  BIOTIC AND ABIOTIC DRIVERS OF SELACHIAN EVOLUTION THROUGHOUT THE CENOZOIC
11:45  E. L. Bernard, S. Sinha, W. J. Pearson, L. T. Gallagher, R. J. Twitchett  ENVIRONMENTAL EFFECTS ON BODY SIZE IN LATE CRETACEOUS LAMNIFORM SHARKS FROM THE ENGLISH CHALK: UNLOCKING HIDDEN DATA IN HISTORIC COLLECTIONS TO ADDRESS KEY SCIENTIFIC QUESTIONS.
12:00  R. L. McKeelby, M. D. Gottfried  QUANTITATIVE ANALYSIS OF ONTOGENETIC VARIATION IN THE DENTITION OF THE GREAT WHITE SHARK (CARCHARODON CARCHARIAS) WITH IMPLICATIONS FOR THE SHARK FOSSIL RECORD

FRIDAY MORNING, OCTOBER 11, 2019
TECHNICAL SESSION XI: MAMMALIAN PALEOECOLOGY AND MACROEVOLUTION
MEETING ROOM M3
MODERATORS: Melissa Pardi and John-Paul Zonneveld

8:00  M. Viteri, M. Stegner, E. A. Hadly  DO RAPTOR PELLETS RECORD SMALL MAMMAL COMMUNITY COMPOSITION OR RAPTOR DIETARY PREFERENCE? A CASE STUDY IN YELLOWSTONE NATIONAL PARK
8:30  H. E. Smith, G. Price, Y. Rizal, J. Zaim, M. Puspaningrum, Aswan, A. Trihascaryo, M. Stewart, J. Louys  A TAPHONOMIC ANALYSIS OF A LATE PLEISTOCENE FOSSIL ASSEMBLAGE FROM NGALAU GUPIN, SUMATRA
8:45  K. Suraprasit, H. Bocherens  STABLE ISOTOPE TRACKING ON TOOTH ENAMEL OF LARGE MAMMALS IN PENINSULAR THAILAND: IMPLICATIONS FOR THE HYPOTHESIS OF AN EQUATORIAL SAVANNA CORRIDOR DURING THE LATE MIDDLE PLEISTOCENE
9:00  N. Fox, J. Southon, G. Takeuchi, A. Farrell, E. Lindsey, J. Blois  BASELINE SHIFTS IN SMALL MAMMAL COMMUNITIES AT RANCHO LA BREA TRACK LATE QUATERNARY ENVIRONMENTAL CHANGES IN SOUTHERN CALIFORNIA
9:15  M. Stegner, E. A. Hadly  LATE HOLOCENE FAUNAL DYNAMICS IN A NORTHERN ROCKY MOUNTAIN FOREST COMMUNITY
9:45  P. Roberts, O. Wedage, N. Amano  QUATERNARY EXTINCTIONS AND NON-EXTINCTIONS ON THE ISLAND OF SRI LANKA AND THEIR RELATIONSHIP TO LATE PLEISTOCENE HOMO SAPIENS
10:15  T. J. Halliday, R. J. Garwood  GEOGRAPHIC PATCHINESS AND ITS EFFECT ON MACROEVOLUTIONARY INFERENCES
10:30  J. Alroy  A WAY TO ACCOUNT FOR BIOGEOGRAPHIC BIAS IN ESTIMATING THE SPECIES RICHNESS OF NORTH AMERICAN CENOZOIC MAMMALS
10:45  C. Badgley, T. Smiley, K. M. Loughney  LANDSCAPE PROCESSES AND DIVERSITY DYNAMICS OF NORTH AMERICAN MAMMALS

WITHDRAWN

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<tr>
<td>11:15</td>
<td>COMPARISON OF ‘BIG DATA’ USES IN PALEOECOLOGICAL MULTI-PROXY MODELS FOR NORTH AMERICAN MAMMALIAN PALEOECOLOGICAL INTERPRETATIONS</td>
<td>D. G. Hock, R. Secord</td>
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<td>11:30</td>
<td>ECOLOGICAL RESPONSE TO LATE MIocene COOLING IN SOUTH AMERICA</td>
<td>M. T. Clementz, B. Carrapa, R. Feng</td>
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<td>11:45</td>
<td>THE ASSEMBLY OF CAT COMMUNITIES IN THE NEW WORLD: ECOMETRICS AND NEOGENE FAUNAL TURNOVER</td>
<td>P. Polly</td>
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<td>12:00</td>
<td>CLARIFYING CLIMATE’S ROLE IN MEGAFAUNAL EXTINCTION THROUGH NICHE MODELING</td>
<td>M. I. Pardi, L. R. Desantis</td>
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**FRIDAY MORNING, OCTOBER 11, 2019**

**TECHNICAL SESSION XII: DINOSAURS II**

**MEETING ROOM M4**

**MODERATORS:** Emma Dunne and Lucy Leahey

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<tr>
<td>8:00</td>
<td>A NEW LAGERPETID ARCHOSAUR FROM THE TRIASSIC OF MADAGASCAR AND THE IMPORTANCE OF MINIATURIZATION IN ORNITHODIRAN EVOLUTION</td>
<td>C. F. Kammerer, S. J. Nesbitt, J. J. Flynn, L. Ranivoharimanana, A. Wyss</td>
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<td>8:15</td>
<td>DINOSAURS DISPARIFY DIFFERENTLY: CONTRASTING PATTERNS OF CRANIAL VARIATION AND MACROEVOLUTION ACROSS DINOSAURS AND CROCODYLOMORPHS</td>
<td>R. N. Felice, A. Watanabe, A. Cuff, M. Hanson, D. Pol, B. S. Bhullar, M. A. Norell, L. M. Witmer, P. M. O’Connor, A. Goswami</td>
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<td>8:30</td>
<td>CRACKING THE EVOLUTIONARY AND DEVELOPMENTAL LINK BETWEEN BRAIN AND SKULL IN ARCHOSAURIA: EVOLUTIONARY AND DEVELOPMENTAL PERSPECTIVES</td>
<td>M. Fabbri, D. S. Paredes, M. Cereghino, J. Botelho, B. Bhullar</td>
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<td>8:45</td>
<td>BODY SIZE CORRELATES WITH DISCRETE CHARACTER MORPHOLOGICAL PROXIES IN DINOSAURS</td>
<td>T. Brougham, N. E. Campione</td>
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<td>9:00</td>
<td>CLIMATE AS A MAJOR CONTROL ON EARLY DINOSAUR GLOBAL DISTRIBUTION</td>
<td>E. M. Dunne, A. Farnsworth, R. B. Benson, S. E. Greene, D. J. Lunt, R. J. Butler</td>
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<td>9:15</td>
<td>USING BIOMECHANICAL MODELLING TO INVESTIGATE AN ADAPTIVE RADIATION: A CASE STUDY IN DINOSAURIA</td>
<td>D. J. Button, L. B. Porro, M. E. Jones, P. M. Barrett</td>
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<tr>
<td>9:30</td>
<td>WERE DINOSAUR ORIGINS ASSOCIATED WITH SUDDEN GLOBAL CLIMATE CHANGE DURING THE CARNIAN PLUVIAL EVENT?</td>
<td>R. Irmis, A. C. Mancuso, C. A. Benavente, J. H. Whiteside, R. Mundil</td>
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<tr>
<td>10:30</td>
<td>INTRASKELETAL VARIATION IN MASSOSPONDYLUS CARINATUS: IMPLICATIONS FOR ONTOGENY</td>
<td>K. E. Chapelle, J. Botha-Brink, J. N. Choiniere</td>
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<tr>
<td>10:45</td>
<td>GEOMETRIC MORPHOMETRIC EVIDENCE FOR RAPID EVOLUTION AND STRONG DIVERSIFYING SELECTION OF PUTATIVE SIGNALLING TRAITS IN HORNED DINOSAURS</td>
<td>A. Knapp, S. Alvarez-Carretero, R. J. Knell, D. W. Hone</td>
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<td>11:00</td>
<td>LONGEVITY AND GROWTH DYNAMICS OF TRICERATOPS AS REVEALED BY FEMORAL HISTOLOGY</td>
<td>J. B. Scannella, H. N. Woodward</td>
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<td>11:15</td>
<td>VARIATION IN BRAINCASE MORPHOLOGY AND PALEONEUROLOGY WITHIN CERATOPSIA</td>
<td>C. Bullar, M. J. Benton, Q. Zhao, M. Ryan</td>
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<td>11:30</td>
<td>MORE THAN MINMI: A NEW AUSTRALIAN ANKYLOSaurIAN DINOSAUR FROM THE LOWER CRETACEOUS (ALBIAN) OF QUEENSLAND, WITH IMPLICATIONS FOR UNDERSTANDING GLOBAL THYREOPHORAN DIVERSITY.</td>
<td>L. G. Leahey, R. E. Molnar, S. W. Salisbury</td>
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<td>12:00</td>
<td>HISTOPATHOLOGY OF A PACHYCEPHALOSAUR FRONTOPARIETAL DOME</td>
<td>A. D. Dyer, A. R. LeBlanc, P. J. Currie</td>
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V. De Pietri, T. H. Worthy, P. Scofield, T. Cole, G. Wragg  
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L. DeSantis, A. Saunders, G. Coulson, J. Dortch  
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T. H. Worthy, L. H. Arnold, A. H. Camens, A. Chinsamy  
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M. Rabi, T. H. Worthy, S. Hawkins, S. Bedford, M. Spriggs  
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G. Sobral, R. Schoch  
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AN EXCEPTIONALLY PRESERVED SMALL ARBOREAL REPTILE FROM THE UPPER PERMIAN USILI FORMATION OF TANZANIA

STILL STRANGER THINGS: µCT IMAGES OF 3D DREpanosaurus (SAINTS & SINNERS QUARRY, LATE TRIASSIC, EOLIAN NUGGET FM.) REVEALS BIZARRE MORPHOLOGIES INCLUDING A BEAK COMBINED WITH TRANSVERSELY WIDE TEETH, SAUROPOD-LIKE PNEUMATIC DORSAL VERTEBRAE, A CHEVRON THAT ARTICULATES WITH THE PELVIS, AND TRIPODAL ADAPTATIONS

V. Vakil, G. E. Webb, A. G. Cook  
VARIATION IN AUSTRALIAN CRETACEOUS SAUROPTERYGIAN AND ICHTHYOPTERYGIAN POSTCRANIAL MATERIAL

B. Kligman, M. R. Stocker, S. J. Nesbitt, A. D. Marsh, W. Parker  
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A. Verriére, J. Fröbisch, N. Fröbisch  
PATTERNS OF OSSIFICATION IN THE VERTEBRAL COLUMN OF AMNIOTES AND THEIR ANCESTRAL CONDITION

M. J. MacDougall, A. Verriére, T. Winrich, A. R. LeBlanc, J. Fröbisch  
CAUDAL AUTOTOMY IN MESOSAURID REPTILES AND ITS IMPLICATIONS FOR ANTI-PREDATORY BEHAVIOUR AND LOCOMOTION IN THE CLADE

R. Chatterji, M. Hutchinson, M. E. Jones  
A QUANTITATIVE ANALYSIS OF SKULL GROWTH AND EVOLUTION IN SEA TURTLES (TESTUDINATA, CHELONIOIDEA)

T. Szczygielski, T. Sulej  
LIMB MORPHOLOGY OF THE LATE TRIASSIC STEM TURTLE PROTEROCHERSIS POROBESENSIS (PROTEROCHERSIDAE)
**R. R. Reisz, J. Bevitt, M. MacDougall**  COMPLEXITY OF EARLY PERMIAN TERRESTRIAL VERTEBRATE COMMUNITY AT RICHARDS SPUR, OKLAHOMA IS REVEALED THROUGH NEUTRON TOMOGRAPHY

**FRIDAY AFTERNOON, OCTOBER 11, 2019**  
**TECHNICAL SESSION XIV: BIRD ORIGIN AND EVOLUTION**  
**MEETING ROOM M4**  
**MODERATORS:** Michael Pittman and Aurore Canoville

1:45  C. T. Griffin, J. Botelho, M. Hanson, M. Fabbri, S. J. Nesbitt, B. Bhullar  
**THE AVIAN PELVIS POSSESSES ANCESTRAL DINOSAURIAN AND ARCHOSAURIAN CHARACTER STATES EARLY IN ONTOGENY**

2:00  M. Pittman, T. Kaye, X. Wang, X. Zheng, S. Hartman, X. Xu  
**INTERNAL AND EXTERNAL FLIGHT-RELATED ANATOMY OF EARLY THEROPOD FLIERS REVEALED BY LASER-STIMULATED FLUORESCENCE FILLS KNOWLEDGE GAPS IN FUNCTIONAL MORPHOLOGY AND FLIGHT CAPABILITY**

**FIRST NON-ORNITHOTHORACINE FOSSIL BIRD (THEROPODA, AVIALAE) FROM THE EARLY CRETACEOUS OF JAPAN: INCREASING OUR UNDERSTANDING ABOUT EVOLUTION AND PALEOBIOGEOGRAPHY OF STEM BIRDS**

**FIRST COMPLETE SKULL THREE-DIMENSIONALLY RECONSTRUCTED FROM EARLY CRETACEOUS BIRDS**

2:45  J. Benito, B. Bhullar, D. Burnham, L. E. Wilson, D. Field  
**NEW ICHTHYORNIS SPECIMENS: SHEDDING NEW LIGHT ON MODERN BIRD ORIGINS**

3:00  S. Wang, D. Hu, R. Wang, X. Xu  
**A NEW BONY-CRESTED, EARLY-DIVERGING AVIALAN FROM THE LOWER CRETACEOUS JEHOL GROUP OF WESTERN LIAONING, CHINA AND ITS IMPLICATION FOR EARLY AVIALAN EVOLUTION**

3:15  S. Hellert, P. Polly, D. P. Rhoda  
**EVOLUTIONARY CONSTRAINT OF THE DIVERSIFICATION OF AVIAN LIMBS**

3:30  S. L. Baumgart, P. C. Sereno  
**PHYLOGENY REPETITIVELY CONSTRAINS BIRD MORPHOLOGY**

3:45  A. Canoville, M. H. Schweitzer, L. Zanno  
**DO FEMALE PENGUINS RESORT TO MEDULLARY BONE AS A SOURCE OF CALCIUM FOR THE EGGSHELL?**

**RECRUITMENT OF CROWN-CLADE PENGUINS INTO NEW ZEALAND**

**FRIDAY AFTERNOON, OCTOBER 11, 2019**  
**REGULAR POSTER SESSION III**  
**GREAT HALL 1&2**

Authors must be present from 4:15 - 6:15 p.m. Friday, October 11

**A NEW LATE PLEISTOCENE SUBFOSSIL SITE (TSARAMODY, SAMBAINA BASIN, CENTRAL MADAGASCAR) WITH IMPLICATIONS FOR THE CHRONOLOGY OF HABITAT AND MEGAFAUNAL COMMUNITY CHANGE ON MADAGASCAR'S CENTRAL HIGHLANDS**

B65  T. Tsubamoto, Y. Kunimatsu, F. K. Manthi, M. Nakatsukasa  
**NEW SPECIMENS OF NYANZACHOERUS (MAMMALIA, ARTIODACTYLA, SUIDAE, TETRACONODONTINAE) FROM THE UPPER MIOCENE NAKALI FORMATION, KENYA**

B66  M. O. Kubo, M. Fujita  
**DIETARY RECONSTRUCTION OF PLEISTOCENE DEER CERVUS ASTYLODON USING DENTAL MICROWEAR TEXTURE ANALYSIS**

B67  M. A. Dantas, A. Cherkinsky, H. Bocherens  
**ISOTOPIC DIET (δ13C) IN A MATHEMATICAL MIXING MODEL: REFINING THE FOOD RESOURCES THAT EXTINCT LARGE HERBIVORES ATE**

B68  T. Deng, X. Wang, S. Hou  
**REPLACEMENT OF ARTIODACTYLS FOR PERISSODACTYLS IN THE CENOZOIC MAMMALIAN FAUNAS OF THE TIBETAN PLATEAU**

B69  O. Cirilli, A. M. Jukar, R. Potts, L. Rook, R. L. Bernor  
**THE DEEP TIME ORIGIN OF AFRICAN ZEBRAS THROUGH THE EURASIAN "EQUUS STENONINE" LINEAGE**

B70  X. Lu, D. Tao  
**NEW POSTCRANIAL MATERIALS OF ACERORHINUS YUANMOUENSIS AND THE PHYLOGENY OF ACERATHERIINAE**

B71  N. Handa  
**A REVIEW OF THE MIOCENE RHINOCEROSES FROM JAPAN, AND PALEOBIOGEOGRAPHIC IMPLICATIONS**

B72  M. C. Coombs, S. Cote  
**CHALICOTHERES OF PAKISTAN: PIECING TOGETHER THE BIOGEOGRAPHIC PUZZLES OF A RARE PERISSODACTYL GROUP IN THE NEOGENE OF SOUTHERN ASIA**
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<td>S. Krumheller, P. M. Gignac, M. R. Stocker, L. Carroll-Garrett, E. Albee</td>
<td>TESTING THE EFFECTS OF PROXY SELECTION ON BITE-FORCE ESTIMATES GENERATED USING INDENTATION SIMULATIONS</td>
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October 2019 PROGRAM AND ABSTRACTS 43
T. L. Adams, K. A. Andrzejewski  REVISITING THE PROCTOR LAKE DINOSAUR LOCALITY: NEW INSIGHTS ON THE PALEOECOLOGY AND PALEOENVIRONMENT

L. J. Hart, P. Bell, E. T. Smith, S. W. Salisbury  A NEW BASAL EUSUCHIAN FROM THE GRIMAN CREEK FORMATION AT LIGHTNING RIDGE, NEW SOUTH WALES, AUSTRALIA.


K. E. Samonds, C. A. Brochu, A. J. Adams, R. B. Rakotozandry  A NEW MIOCENE CROCODILIFORM FROM THE ISLAND OF NOSY MAKAMBY, NORTHWESTERN MADAGASCAR

C. Chiotakis  DETERMINING AUSTRALIAN PLIO–PLEISTOCENE CROCODILIAN DIVERSITY USING THREE DIMENSIONAL MORPHOMETRICS OF DENTAL AND OSTEODERM REMAINS

R. Rakotozandry, H. T. Andrianavalona, K. E. Samonds  SUBFOSSIL CROCODYLNIANS FROM A NEW LATE PLEISTOCENE SUBFOSSIL SITE (TSARAMODY, SAMBAINA BASIN, CENTRAL MADAGASCAR).

D. B. Norman  SCELIDOSAURUS, A POORLY KNOWN AND MISUNDERSTOOD ORNITHISCHIAN DINOSAUR

J. Russo, O. Mateus  A NEW ANKYLOSAR DINOSAUR SKELETON FROM THE UPPER JURASSIC OF PORTUGAL


L. Jia, H. You, S. Wang, S. Xu  NEW DISCOVERY OF ANKYLOSAR FOSSILS FROM SHANXI PROVINCE, CHINA

C. A. Forster, M. R. Spencer, K. E. Poole, J. M. Clark, X. Xu  A NEW NEORNITHISCHIAN (CERAPODAN?) DINOSAUR FROM THE OXFORDIAN SHISHUGOU FORMATION OF CHINA: WHAT IS AN ORNITHOPOD?

B. Allison, T. Lamaster, H. M. Avrahami, L. Zanno  BUCCAL TOOTH DEVELOPMENT, REPLACEMENT RATE, AND MICROSTRUCTURE IN PARKSOSAURIADA. (DINOSAURIA: NEORNITHISCHIA)


J. A. Case, M. C. Lamanna, R. C. Ely  AN ASSOCIATED ORNITHOPOD DINOSAUR HIND LIMB FROM THE UPPERMOST CRETACEOUS (MAASTRICHTIAN) LOPEZ DE BERTODANO FORMATION OF THE JAMES ROSS BASIN, WEST ANTARCTICA

A. Prieto-Marquez, J. R. Wagner, T. M. Lehman  AN UNUSUAL NON-SAuroLOPHID ‘DUCK-BILLED’ DINOSAUR FROM THE EARLY CAMPANIAN (CRETACEOUS) OF TRANS-PECOS TEXAS, AND THE ANCESTRAL HADROSARURIAN CREST

T. A. Gates, J. Sertich  REDIAGNOSIS OF PARASAuroLOPHUS CYROCTOCRISSTATUS BASED ON NEW MATERIAL FROM THE FRUITLAND FORMATION, NORTHWESTERN NEW MEXICO

J. Bourke, T. A. Gates, L. Zanno  NASAL PASSAGE GROWTH THROUGH ONTOGENY IN THE LAMBEOSAURINE PARASAuroLOPHUS (ORNITHOPODA: DINOSAURIA)


S. J. Rufolo, J. Mallon, M. Currie, T. W. Dudgeon, A. McDonald, S. Swan, T. C. Wyenberghenzer  NEW CONTRIBUTIONS TO THE CERATOPSID RECORD OF THE DINOSAUR PARK FORMATION FROM RECENT FIELDWORK ALONG THE SOUTH SASKATCHEWAN RIVER, ALBERTA, CANADA

S. R. Carpenter, M. A. Loewen, K. Chiba, E. K. Lund, E. M. Roberts  NEW CENTROSAURINE CERATOPSIANS FROM THE CAMPANIAN WAHWEAP FORMATION OF UTAH

D. J. Stefanski  CRANIOFACIAL ONTOGENY IN PACHYCERHALOSAURUS WYOMINGENSIS
SATURDAY MORNING, OCTOBER 12, 2019
SYMPOSIUM: ORIGIN OF A SUNBURNED COUNTRY: DEVELOPMENT OF THE MODERN AUSTRALIAN VERTEBRATE FAUNA FROM THE LATE MIocene ONWARDS
MEETING ROOM M3
MODERATORS: Robin Beck and Pip Brewer

8:00 R. M. Beck, R. K. Engelman, K. Travouillon  MACROEVOLUTIONARY DYNAMICS OF SOUTH AMERICAN AND AUSTRALIAN FAUNIVOROUS MARSUPIALS DURING THE NEOGENE
8:15 P. Brewer  DIETARY NICHE SEPARATION IN LATE MIocene TO RECENT HYPSELODONT WOMBATS
8:30 J. M. Nguyen  A FLOCK OF FOSSILS: NEW FOSSIL EVIDENCE ON THE EVOLUTION OF AUSTRALIAN SONGBIRDS (PASSERIFORMES)
8:45 S. Wroe, R. Mitchell  CRUSHING IT: THE SPECIALISED CRANIAL MECHANICS OF AN EXTINCT SHORT-FACED KANGAROO
9:00 P. M. Oliver, M. S. Lee, C. Hipsley  HOW 'OLD' IS THE AUSTRALIAN ARID ZONE: A HERP'S EYE VIEW ACROSS MOLECULES AND MORPH.
10:15 P. Priya  RECONSTRUCTING THE LATE PLEISTOCENE CLIMATE SEQUENCE AT ALEXANDRA CAVE, NARACOORTE, SOUTH AUSTRALIA, USING SINGLE-GRAIN OPTICALLY STIMULATED LUMINESCENCE DATING AND PALEOENVIRONMENTAL PROXIES
10:30 M. McDowell  THE PRE-EUROPEAN MAMMALS OF TASMANIA: WAS THE BASSIAN PLAIN A BRIDGE OR BARRIER?
10:45 M. Archer, P. R. Fabian, M. Hari-Rajan, S. J. Hand, J. Wolfe, L. A. Wilson, T. Hung, A. Bongers  NEW CENOZOIC ACROBATID POSSUMS FROM THE RIVERSLEIGH WORLD HERITAGE FOSSIL DEPOSITS, AUSTRALIA, AND INVESTIGATION OF THEIR BIZARRE MIDDLE EAR STRUCTURE
11:00 K. Butler, K. Travouillon, V. Weisbecker, A. R. Evans, L. Murphy, G. Price, M. Archer, S. J. Hand  FANGAROOS AND KANGAROOS: PHYLOGENY, PALEOEKOLOGY, DIVERSIFICATION, AND EXTINCTION OF EARLY KANGAROOS (MARSUPIALIA, MACROPODIFORMES) FROM THE RIVERSLEIGH WORLD HERITAGE AREA
11:15 I. A. Kerr  A UNIQUE ARTICULATED FOSSIL SHEDS LIGHT ON THE TAXONOMY OF TWO PLEISTOCENE SPECIES OF GIANT KANGAROO FROM THE GENUS PROTEMNODON
11:45 A. B. Camens, T. H. Worthy  WALK LIKE A KANGAROO: NEW FOSSIL TRACKWAYS REVEAL A BIPEDALLY STRIDING MACROPODID IN THE PLIOCENE OF CENTRAL AUSTRALIA

SATURDAY MORNING, OCTOBER 12, 2019
TECHNICAL SESSION XV: FINS TO LIMBS
MEETING ROOM M1&2
MODERATORS: Zoe Kulik and Martin Sander

8:00 Y. Hu, G. Young, J. Lu  CONSTRUCTIONAL MORPHOLOGY OF THE SHOULDER GIRDLE AND OPERCULAR SERIES OF THE UPPER DEVONIAN TETRAPODOMORPH GOGONASUS FROM WESTERN AUSTRALIA
8:30 M. E. Jones, L. E. Hill, R. B. Benson, S. E. Evans  THREE DIMENSIONAL SKELETONS OF MIDDLE JURASSIC STEM-GROUP SALAMANDERS FROM SCOTLAND, UK
THE EARLIEST KNOWN OCCURRENCES OF AN EDENTULOUS FROG AND POSSIBLE SIRENID SALAMANDER FROM THE CLOVERLY FORMATION (ALBIAN) OF WYOMING, U.S.A.

A NEW RHAETIAN BONEBED FROM GERMANY: IMPLICATIONS FOR THE END-TRIASSIC EXTINCTIONS IN THE MARINE REALM

THE VERTEBRATE PALEONTOLOGY OF THE LOWER TRIASSIC FREMOUW FORMATION IN THE SHACKLETON GLACIER AREA (ANTARCTICA)

A NEW PRIMITIVE CASEASAURIAN SYNAPSID FROM THE EARLY PERMIAN OF CENTRAL GERMANY AND ITS IMPLICATIONS FOR THE EVOLUTION OF DENTITIONS, DIETS, AND HERBIVORY OF CASEIDS

STERNAL EVOLUTION IN SYNAPSIDA AND THE ORIGIN OF THE MAMMALIAN STERNUM

THE FIRST NON-MAMMALIAN CYNODONTS FROM AUSTRALIA AND THE UNUSUAL NATURE OF AUSTRALIAN CRETACEOUS CONTINENTAL TETRAPOD FAUNAS

BIOSTRATIGRAPHY OF THE LOWERMOST BEAUFORT GROUP IN THE MAIN KAROO BASIN, SOUTH AFRICA: IMPLICATIONS FOR MID- TO LATE-PERMIAN FAUNAL PROVINCIALISM AND KAROO BASIN DEVELOPMENT

COMPARATIVE HISTOLOGY OF DICYNODONT TUSKS REVEALS CRYPTIC DIVERSITY OF TISSUE COMPOSITION, DEVELOPMENT, AND ATTACHMENT STRATEGIES

MORE THAN ONE WAY TO BE A BOSS: HISTOLOGICAL PERSPECTIVES ON CRANIAL BOSS DEVELOPMENT AND ITS EFFECT ON SUTURE MORPHOLOGIES

FILLING OLSON’S GAP? A RE-APPRAISAL OF RARANIMUS DASHANKOENSIS (SYNAPSIDA, THERAPSIDA) USING CT SCANNING TECHNOLOGIES AND BAYESIAN ANALYSIS

RATES OF MORPHOLOGICAL EVOLUTION IN ANOMODONTIA (THERAPSIDA) ACROSS THE END-PERMIAN MASS EXTINCTION

ALLIGATORINE DIVERSITY DYNAMICS SUPPORT THE COMMON-CAUSE HYPOTHESIS OF MACROEVOLUTIONARY PATTERNS IN THE ROCK RECORD

SATURDAY MORNING, OCTOBER 12, 2019
TECHNICAL SESSION XVI: DINOSAURS III
MEETING ROOM M4
MODERATORS: James Neenan and Matt Lamanna

OBSERVATIONS ON THE MORPHOLOGICAL SUPPORT FOR ORNITHOSCELIDA HUXLEY, 1870

PERINATAL REMAINS SHOW THAT NON-AVIAN AND AVIAN DINOSAURS NESTED IN THE LATE CRETACEOUS PALEO-ARCTIC OF NORTHERN ALASKA

A NEW AND WELL-PRESERVED EARLY-DIVERGING ABELISAURID (THEROPODA: CERATOSAURIA: ABELISAUROIDEA) FROM THE EARLY LATE CRETACEOUS OF NORTHERN PATAGONIA

A NEW DESCENT-DWELLING NOASAURINE THEROPOD FROM THE CAIÚÉ GROUP, CRETACEOUS OF SOUTH BRAZIL

NEW INSIGHTS INTO ALLOSAURUS FRAGILIS MARSH, 1877 (DINOSAURIA, THEROPODA) FROM THE TOPTYPE SPECIMEN, USNM 4734

SIZE AND MASS DON’T COVARY WITH MATURITY AMONG ADULT SPECIMENS OF T YRANNOSAURUS REX

EVOLUTIONARY RATES IN TYRANNOSAURIDS SUPPORT A MODEL OF ECOLOGICAL RELEASE LINKED TO THE EXTIRPATION OF CARCHARODONTOSAURIANS

CONVERGENT SENSORY ECologies BETWEEN ALVAREZSAUROIDEA AND EXANT YTONTID OWLS

10:30  M. Ma, X. Xu, S. Wang  CRANIAL ONTOGENETIC VARIATIONS OF SINORNITHOMIMUS DONGI (DINOSAURIA: ORNITHOMIMOSAURIA)


11:00  P. M. O’Connor, A. H. Turner, J. R. Greenke, R. N. Felice, R. R. Rogers  A NEW AVIALAN FOSSIL FROM THE MAEVARANO FORMATION, MAHAJANGA BASIN, NW MADAGASCAR, EXPANDS KNOWN CRANIAL SHAPE DISPARITY AMONG MESOZOIC BIRDS VIA AN EXPANDED MAXILLA CONTRIBUTING TO ENHANCED ROSTRALIZATION

11:15  T. L. Green, P. M. Gignac  ESTABLISHING A COMPARATIVE OSTEO-DEVELOPMENTAL FRAMEWORK FOR EVOLUTIONARY AND FUNCTIONAL STUDIES OF DINOSAUR HEADGEAR THROUGH ANALOGY TO SOUTHERN CASSOWARIES AND NEOGNATHOUS BIRDS

11:30  N. Carroll, G. P. Wilson, D. G. Demar, L. M. Chiappe  A COPROLITE-PRESERVED FEATHER ASSEMBLAGE FROM THE UPPER CRETAEOUS HELL CREEK FORMATION

11:45  T. R. Lyons, J. M. Miller, A. D. Bercovicci  CHANGES IN DINOSAUR ECOSYSTEMS FROM THE HELL CREEK FORMATION LEADING UP TO THE CRETAEOUS-PALEOGENE BOUNDARY IN NORTH AMERICA

12:00  T. Kubo  BIOGEOGRAPHICAL NETWORK ANALYSIS OF CRETAEOUS NON-AVIAN DINOSAURS AND BIOGEOGRAPHICAL CONNECTIONS OF AUSTRALIA TO OTHER CONTINENTS

SATURDAY AFTERNOON, OCTOBER 12, 2019
TECHNICAL SESSION XVII: MESOZOIC AND PALEOGENE MAMMALS
MEETING ROOM M1&2
MODERATORS: Luke Weaver and Sarah Shelley

1:45  F. Mao, C. Li, Y. Wang, J. Meng  3D-RECONSTRUCTION OF MULTIPLE SPECIMENS FROM THE LOWER CRETAEOUS OF CHINA REVEALS CHARACTER CO-EVOLUTION TOWARD THE BAUPLAN OF BASAL THERIANS

2:00  S. Bi, J. R. Wible, X. Zheng, X. Wang  THE EARLY CRETAEOUS EUTHERIAN AMBOLESTES AND ITS IMPLICATIONS FOR THE EUTHERIAN-METATHERIAN DICHOTOMY

2:15  L. N. Weaver, G. P. Wilson, E. J. Sargsis, W. J. Freimuth, D. J. Varricchio  EXCEPTIONALLY PRESERVED SKELETONS FROM THE LATE CAMPANIAN OF MONTANA PROVIDE A UNIQUE GLIMPSE INTO THE PALEOBIOLOGY OF MULTITUBERCULATES


3:00  J. R. Claytor, G. P. Wilson, W. A. Clemens  EARLIEST PUERCAN 1 (PU1) FAUNAS FROM MONTANA WITH INSIGHTS ON MAMMALIAN TAXONOMIC AND ECOLOGICAL RECOVERY AFTER THE K–PG MASS EXTINCTION EVENT

3:15  S. L. Shelley, S. Brusatte, T. E. Williamson  HIGH LOCOMOTOR DIVERSITY IN EARLY PALEOGENE MAMMALS PROVIDES ECOMORPHOLOGICAL INSIGHT INTO EVOLUTION FOLLOWING THE END-CRETACEOUS MASS EXTINCTION

3:30  B. T. Hovatter, G. P. Wilson  COMPOSITION OF NEWLY DESCRIBED EARLIEST TORREJONIAN (TO1) FAUNA FROM NORTHEASTERN MONTANA, U.S.A. REVEALS TAXONOMIC DIFFERENCES AMONG EARLY PALEOCENE FAUNAS IN THE WESTERN INTERIOR OF NORTH AMERICA AND HIGHLIGHTS NORTH-SOUTH PROVINCIALITY


4:00  Y. Gong, Y. Wang, Y. Wang, F. Mao, B. Bai, H. Wang  DIET AND ECOLOGY OF TWO LOPHALETIDS FROM THE EOCENE OF ERLIAN BASIN, CHINA: COMBINED EVIDENCE FROM MESOWEAR AND STABLE ISOTOPE ANALYSES
SATURDAY AFTERNOON, OCTOBER 12, 2019
TECHNICAL SESSION XVIII: EVOLUTIONARY AND FAUNAL STUDIES
MEETING ROOM M3
MODERATORS: Phil Bell and Matthew Phillips


2:00  P. R. Bell, N. E. Campione, E. T. Smith, L. Milan  MID-CRETACEOUS ENDEMICITY OF EASTERN AUSTRALIAN VERTEBRATE FAUNAS

2:15  V. Fischer, L. C. Soul, R. B. Benson, M. S. Friedman  WANING AND WAXING MARINE REPTILE DIVERSITY PRIOR TO THE K-PG BOUNDARY


2:45  R. A. Close, R. B. Benson, R. J. Butler  SPECIES-AREA RELATIONSHIPS IN NORTH AMERICAN TERRESTRIAL TETRAPODS ACROSS THE CRETACEOUS/PALEOGENE BOUNDARY

3:00  M. J. Phillips, C. Fruciano  EXPLAINING WHY MOLECULAR CLOCK ANALYSES MISSED THE POST K–PG DIVERSIFICATIONS OF MAMMALS AND BIRDS OBSERVED IN THE FOSSIL RECORD

3:15  A. S. Schulp, O. Mateus, M. Polcyn, A. Gonçalves, L. L. Jacobs  ANGOLA AND ITS ROLE IN THE PALEOBIOGEOGRAPHY OF GONDWANA

3:30  I. M. Miller, T. R. Lyson, A. Bercovici  PLANT EVOLUTION AND DIVERSIFICATION SHAPED VERTEBRATE ECOSYSTEMS DURING THE LATE CRETACEOUS AND EARLY PALEOGENE IN WESTERN NORTH AMERICA

4:00  J. R. Moore  VERTEBRATE TAPHONOMY IN DISTRIBUTIVE FLUVIAL SYSTEMS

SATURDAY AFTERNOON, OCTOBER 12, 2019
TECHNICAL SESSION XIX: TERRESTRIAL LOCOMOTOR BIOMECHANICS
MEETING ROOM M4
MODERATORS: Christian Heck and Peter Bishop

1:45  K. I. Lennie, S. Manske, C. Mansky, J. Anderson  USING TRABECULAR ANISOTROPY TO DETERMINE THE POTENTIAL FOR WALKING LIMBS IN A DIVERSE ARRAY OF EARLY TETRAPODS FROM BLUE BEACH, NOVA SCOTIA

2:00  R. W. Blob, V. K. Young, V. D. Munteanu, C. J. Mayerl, K. M. Diamond, S. M. Kawano  BIOMECHANICAL RELEASE: LOADING REDUCTION AS A PATHWAY FOR MORPHOFUNCTIONAL CHANGE IN THE SKELETONS OF VERTEBRATES ACROSS EVOLUTIONARY TRANSITIONS IN HABITAT

2:15  T. Hirasawa, S. Kuratani  DECIPHERING DEVELOPMENTAL CONSTRAINTS IN LIMB MUSCLES

2:30  O. E. Demuth, E. J. Rayfield, J. R. Hutchinson  3D LIMB BIOMECHANICS OF THE STEM-ARCHOSAUR EUPARKERIA CAPENSIS

2:45  A. Cuff, A. Otero, J. R. Hutchinson  FUNCTIONAL DISPARITY IN TRIASSIC–JURASSIC ARCHOSAUR HINDLIMBS, AND IMPLICATIONS FOR MUSCULOSKELETAL MODELLING

3:00  P. J. Bishop, A. Falisse, F. De Groote, J. R. Hutchinson  USING DYNAMIC OPTIMIZATION TO SIMULATE LOCOMOTION IN EXTANT AND EXTINCT ARCHOSAURS

3:15  D. Drózdź, T. Sułej  LIMB OSTEOLOGY AND PROBABLE DIGGING ADAPTATIONS IN THE AETOSAUR STAGONOLEPSIS OLENAE (ARCHOSAURIA: PSEUDOSUCHIA) FROM NORTHERN PANGEA

3:30  M. D. Stein, L. A. Wilson, S. J. Hand, M. Archer  GEOMETRIC MORPHOMETRIC AND FINITE ELEMENT ANALYSIS OF THE MEKOSUCHINE CROCODILE FORELIMB AS AN ASSESSMENT OF LOCOMOTION

3:45  A. Jannel, S. W. Salisbury, O. Panagiotopoulou  STANDING ON THE FEET OF GIANTS: FINITE ELEMENT ANALYSES OF SAUROPOD DINOSAURS HIND FEET AND THE EVOLUTION OF GIGANTISM

4:00  C. Heck, H. Woodward Ballard  AN ARM AND A LEG: TESTING ONTOGENETIC POSTURE CHANGE IN MAIASAURA PEEBLESORUM THROUGH LIMB SCALING AND OSTEOHISTOLOGY

J. M. White, M. McCurry, A. R. Evans — EVALUATING THE DIET OF HULITHERIUM USING ORIENTATION PATCH COUNT (OPC)

Y. Gurovich, K. W. Ashwell — PHYLOGENY OF SOUTH AMERICAN MARSUPIAL DROMICIOPS THROUGH BRAIN TRAITS

A. C. Tschirn, A. B. Camens — NEW SKELETAL MATERIAL SHEDS LIGHT ON THE EVOLUTION AND PALEOBIOLOGY OF KOALAS

T. J. Churchill, M. Archer, S. J. Hand — A NEW HYPERSPECIALISED CARNIVOROUS DASYUROMORPHIAN MARSUPIAL FROM EARLY MIocene DEPOSITS IN THE RIVERSLEIGH WORLD HERITAGE AREA, NORTH-WESTERN QUEENSLAND


C. M. Janis, A. Wagstaffe, C. Kunz, E. J. Rayfield — BONE MICROANATOMY IN KANGAROOS INDICATES DIFFERENT MODES OF LOCOMOTION IN MACROPODINES AND STHENURINES

J. D. Van Zoelen, A. B. Camens, G. J. Prideaux — RESOLVING THE TAXONOMIC VALIDITY OF THE GIANT EXTINCT MARSUPIAL NOTOTHERIUM (DIPROTONDONTIDAE) AND ITS RELATIONSHIP TO ZYGOMATURUS

M. L. Martin, N. M. Warburton, K. J. Travoillon, T. A. Fleming — A COMPARATIVE FUNCTIONAL ANALYSIS OF FORELIMB MORPHOLOGY IN AUSTRALIAN MARSUPIALS (MARSUPIALIA)

A. H. Parker, M. Archer, S. J. Hand, T. Myers — TAPHONOMY AND PALEOCOMMUNITY STRUCTURE OF LD94 SITE, A MIDDLE MIocene FOSSIL DEPOSIT IN THE RIVERSLEIGH WORLD HERITAGE AREA, NORTHWESTERN QUEENSLAND


Y. Li, S. Bi, T. Deng — SKULL REMAINS OF A SMALL FELINE (CARNIVORA, FELIDAE) FROM THE LATE MIocene DEPOSITS OF LINXIA BASIN (GANSU PROVINCE, CHINA)

F. O’Keefe, A. Brannick — SPACE-INDEPENDENT MEASURES OF MODULARITY IN GEOMETRIC MORPHOMETRICS, WITH AN EXAMPLE FROM SMILODON AND CANIS DIRUS


M. Balisi, J. Blois, A. Farrell, G. Takeuchi, E. Lindsey — CHARACTERIZING MESOCARNIVORE DISTRIBUTIONS AT RANCHO LA BREA

D. Flores, E. Eldridge, E. Elminowski, A. Hartstone-Rose — THE ROAR AND HOWL OF RANCHO LA BREA’S TOP PREDATORS

H. Chirchir, C. Ruff, K. Helgen, R. Potts — TRABECULAR BONE DENSITY IN ZOO AND WILD FELIDS

R. López-Antoñanzas, P. Pérez-Campones, D. Azar, G. Kachacha, A. Prieto-Márquez, F. Knoll — FIRST MYOCRICETODONTINAE (RODENTIA) FROM THE MIocene OF LEBANON

S. López-Torres, R. Bhagat, M. T. Silcox, L. Fostoviecz-Frelik — FIRST VIRTUAL RECONSTRUCTION OF THE INNER EAR OF A FOSSIL RABBIT: LOCOMOTOR BEHAVIOUR AND HEARING SENSITIVITY OF MEGALAGUSTURGIDUS (EARLY OLIGOCENE OF NEBRASKA)

T. Kato, H. Yamano — DISCOVERY OF A NEW RODENT ASSEMBLAGE FROM THE LATE OLIGOCENE IN JAPAN

S. F. Alashqar, H. M. Sallam, S. El-Sayed, E. M. Seiffert — NEW PHIOCRICETOMYINE RODENTS (PHIOMORPHA, HYSTRICOGNATHI) FROM THE JEBEL QATRANI FORMATION, FAYUM DEPRESSION, EGYPT
B87 T. A. Penkrot, S. P. Zack  NEW POSTCRANIA OF SCIURAVIDAE (RODENTIA): IMPLICATIONS FOR LOCOMOTION AND PHYLOGENY


B89 N. A. Singh, Y. P. Singh, K. M. Sharma, N. P. Singh, R. Patnaik  ADDITIONAL FOSSILS REMAINS FROM THE HOMINOID BEARING LATE MIOCENE TAPPAR LOCALITY OF KUTCH, INDIA: IMPLICATION ON PALEOENVIRONMENT

B90 M. J. Ziegler, D. W. Steadman, J. M. Jaeger, V. J. Perez, B. J. Macfadden  PALEOENVIRONMENTAL ANALYSIS OF AN UNUSUAL FOSSIL LOCALITY FROM THE LATE MIOCENE IN NORTHERN FLORIDA

B91 K. M. Sharma, Y. P. Singh, N. A. Singh  RECORDS OF VERTEBRATE REMAINS FROM THE LATE TRIASSIC TIKI FORMATION, MADHYA PRADESH, INDIA: IMPLICATIONS ON GONDWANAN PALEOBIOGEOGRAPHY

B92 G. S. Gonçalves, C. A. Sidor  A NEW DREPANOSAUROMORPH FROM THE CHINLE FORMATION OF PETRIFIED FOREST NATIONAL PARK, ARIZONA

B93 M. Talanda, T. Sulej  AN EARLY LATE TRIASSIC RHYNCHOCEPHALIAN FROM NORTHERN PANGAEA SUGGESTS RELIC NATURE OF SOME BRITISH RHAETIAN VERTEBRATE ASSEMBLAGES

B94 K. M. Jenkins, K. Schwenk, B. S. Bhullar, J. A. Gauthier  TOOTH ATTACHMENT IN AN ACRODONT AMPHISBAENID (SQUAMATA)

B95 C. J. Bell, S. G. Scarpetta, D. Anderson  DIAGNOSTIC EFFICACY OF PUBLISHED MORPHOLOGICAL CHARACTERISTICS OF NORTH AMERICAN SAND LIZARDS

B96 R. Allemand, J. Abdul-Sater, M. T. Silcox  ENDOCRANIAL ANATOMICAL CHANGES THAT ACCOMPANY THE LOSS OF LIMBS IN SQUAMATES

B97 M. Riegler, E. L. Stanley, J. I. Bloch  DESCRIBING ENAMEL IN SQUAMATES: UTILIZING NON-DESTRUCTIVE CT SCANS TO CHARACTERIZE ENAMEL IN EXTANT AND EXTINCT LIZARD SPECIES

B98 S. J. ElShafie  BODY SIZE CHANGES ACROSS LIZARDS AND CROCODYLIANS CORRESPOND TO CLIMATIC CHANGES THROUGH THE PALEOGENE IN THE WESTERN INTERIOR OF NORTH AMERICA


B100 W. R. Callahan, C. M. Mehling, S. Ballwanz, T. W. Dudgeon  FIRST EVIDENCE OF CHAMPSOSAURS (DIAPSIDA; NEOCHORISTODERA) FROM THE LATE CRETACEOUS OF THE ATLANTIC COASTAL PLAIN

B101 Y. Lee, D. Kong, S. Jung  THE FIRST CHORISTODERAN TRACKWAY?

B102 Y. Nakajima, R. Matsumoto, P. M. Sander, O. Sasaki, H. Kano, S. Hayashi, S. E. Evans  MINERALIZED NOTOCHORD-ASSOCIATED TISSUES PRESERVED IN FOSSIL CENTRA SUGGESTS A UNIQUE DEVELOPMENTAL PATTERN IN THE AXIAL SKELETON OF CHORISTODERA


B104 M. O. Day, J. Ramezani, R. Frazer, B. S. Rubidge  U–PB (CA-TIMS) AGE CONSTRAINTS ON THE MIDDLE PERMIAN LAND VERTEBRATE EVOLUTION FROM THE MAIN KAROO BASIN, SOUTH AFRICA


B107 J. Liu, J. Yi  NEW TETRAPODS FROM THE SUNJIAGOU FORMATION AND SHANGSHIHEZI (UPPER SHIHHOTSE) FORMATION, SHANXI, CHINA AND THEIR IMPLICATIONS

B108 E. M. Knutsen  THE LAZARUS DICYNODONT—REASSESSING AUSTRALIAN CRETACEOUS MATERIAL


B110 M. B. McCabe, S. J. Nesbitt  THE FIRST PECTORAL AND FORELIMB MATERIAL ASSIGNED TO THE LAGERPETID LAGERPETON CHANARENSIS: COMPARING TO OTHER LAGERPETIDS AND OTHER AVEMETATARSALIANS

B111 J. Botha, K. Chapelle, B. Weiss, J. N. Choiniere  LIFE HISTORY PATTERNS IN EARLY JURASSIC DINOSAURS FROM SOUTH AFRICA

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S. Hartman  USING COMPARATIVE ANATOMY, TAPHONOMY, AND PHYLOGENETIC BRACKETING TO ASSESS RIB ORIENTATION IN NON-AVIAN DINOSAURS

M. Lambertz  ON THE HISTOLOGY AND DEVELOPMENT OF DINOSAURIAN POST-CRANIAL SKELETAL PNEUMATICITY

N. Campione, J. Mallon, R. Benson, A. R. Evans  ON THE POTENTIAL TO RECONSTRUCT A DIETARY CONTINUUM IN DINOSAURS

D. J. Varricchio, W. J. Freimuth, G. Panasci  THE RICH ICHNOLOGIC RECORD OF EGG MOUNTAIN FROM THE TWO MEDICINE FORMATION (UPPER CRETACEOUS) OF MONTANA, USA, PROVIDES INSIGHT INTO THE ENVIRONMENT, SEDIMENTOLOGY AND ECOLOGY OF A DINOSAUR NESTING SITE

S. Whitebone, G. F. Funston, P. J. Currie  AN UNUSUAL FOSSIL LOCALITY FROM THE LATE CRETACEOUS HORSESHOE CANYON FORMATION OF SOUTHERN ALBERTA, CANADA REVEALS RARE ELEMENTS OF A PALEOCOMMUNITY

A. M. Jukar, M. T. Carrano  THE STRUCTURE OF THE MAMMALIAN AND DINOSAURIAN HERBIVORE GUILD


E. M. Roberts, T. Beveridge, J. Ramezani, A. Titus  INTRAFORMATIONAL STRATIGRAPHIC CORRELATION OF VERTEBRATE LOCALITIES WITHIN THE UPPER CRETACEOUS KAIPAROWITS FORMATION TIED TO HIGH-PRECISION U–PB CA-ID-TIMS ZIRCON DATING OF 11 BENTONITE MARKER HORIZONS: IMPLICATIONS FOR EVOLUTIONARY AND ECOLOGICAL PATTERN

A. R. Fiorillo, Y. Kobayashi, P. McCarthy  COMPARISON OF PALEOENVIRONMENTAL AND PALEOClimatological PARAMETERS OF CORRELATIVE DINOSAUR-BEARING LATE CRETAceOUS (Campanian–Maastrichtian) ROCK UNITS ACROSS ALASKA, USA: A REGIONAL PERSPECTIVE

B. S. Salem, H. M. Sallam, S. El-Sayed, W. Thabet, M. Antar, M. C. Lamanna  NEW DINOSAUR, PTerosaur, AND CROCODyLIFORM FOSSILS FROM THE UPPER CRETAceOUS (CenoMANIAN) BahariYa FORMATION OF THE BahariYa oasIS, EGYPT

B. H. Breithaupt, N. A. Matthews, T. L. Green, M. Belvedere  INSIGHTS INTO DINOSAUR TRACKING IN THE 21ST CENTURY USING PHOTOGRAMMETRIC ICHNOLOGY AND NEOICHNOLOGY OF EMUS

M. V. Connelly, J. Cavigelli  TATE GEOLUTIONARY MUSEUM—A VALUABLE RESOURCE FOR VERTEBRATE PALEONTOLOGICAL RESEARCH AS WELL AS ENHANCING LIBERAL ARTS EDUCATION
**REVISITING THE PROCTOR LAKE DINOSAUR LOCALITY: NEW INSIGHTS ON THE PALEOECOLOGY AND PALEOENVIRONMENT**

ADAMS, Thomas L., Witte Museum, San Antonio, TX, United States of America; LEHRMANN, Daniel, Trinity University, San Antonio, TX, United States of America; DESCHNER, Everett, The Heritage Museum of the Texas Hill Country, between the communities of Sattler and Startzville in Comal County, preserves over 300 footprints from the early Cretaceous (~110 million years ago) Glen Rose Formation. Originally discovered in 1982, the HMTHC has been essential in the study of other dinosaur track and fossil localities throughout the Hill Country. Because dinosaur footprints have been an integral part of the human experience as well as geological history of Texas, it is imperative that this wonderful site and all of its natural resources be preserved for future generations.

Preparators' Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)

**MILLIONS OF YEARS, DOZENS OF SAMPLES, ONE SINGLE SCAN: NEW METHODS TO RAPIDLY INCREASE THE NUMBER OF SPECIMENS CAPTURED IN A SINGLE HIGH-QUALITY SCAN.**

AGUILAR, ROCIO, Museums Victoria/Monash University/University of Melbourne, Melbourne, Australia

High-resolution microcomputed tomography, or microCT, has become an increasingly valuable tool for the non-invasive visualization of small objects. MicroCT is particularly beneficial for the study of museum collections, which often contain millions of small, delicate, and unique objects not amenable to traditional preparation. Despite the increasing use of microCT in systematic biology, a major challenge remains in the practical imaging of high numbers of small specimens within a project scope, for example in the context of large-scale analyses of community change over time. This has proven difficult because of the need for specimens to remain motionless during scan time and because each individual must be digitally labelled to match the original specimen’s identity. Here we outline steps developed for the high throughput microCT scanning of micro-fossils (~2mm), meant to facilitate advanced exploration of museum collections, and allow researchers with limited access to microCT facilities the opportunity to maximize their investments. We based our studies on micro-fossils from Capricorn Caves in Queensland, Australia, to study changes in morphology, ecology and distribution of reptiles, amphibians and mammals. We succeed in maximizing the quality of samples per scan in order to obtain high quality 3D models and compare them to their modern counterparts. These steps should also be applicable to any small, dry objects of similar properties and size.

Grant Information:

This work was supported by the Australian Research Council DE180100629 to C.A.H.

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Grant Information:
This research is supported by funds from NSF GP-EXTRA GeoPATHS program, grant numbers 1600410 and 1600545.

Technical Session VI (Thursday, October 10, 2019, 8:30 AM)

MACRONYCTERIS — A MORPHOMETRIC ASSESSMENT OF MODERN AND EXTINCT MACRONYCTERIS SPP. (CHIROPTERA: HIPPOSIDERIDAE) ON MADAGASCAR

ALUMBAUGH, Jamie L., Northern Illinois University, Sycamore, IL, United States of America; SAMONDS, Karen, Northern Illinois University, Dekalb, IL, United States of America; GOODMAN, Steven M., Field Museum of Natural History, Chicago, IL, United States of America; GODFREY, Laurie, University of Massachusetts Amherst, Amherst Center, MA, United States of America

Extant Macronycteris spp. bats are broadly distributed across Madagascar, and vary in size with respect to their sex, biogeographic origin and genetic clade. An extinct member of the genus, Macronycteris baua, was identified from a late Miocene (−10.000 year-old) site in Anjohibe Cave in northwestern Madagascar. Since its description, taxonomic and phylogenetic revisions of living Macronycteris spp. have reshaped our understanding of the genus. This includes the discovery of a new cryptic species, M. cryptovalorona, and two
clades within *M. commersonii*. Furthermore, augmentation of well
documented museum collections has permitted more comprehensive assessment of the morphological trends within the extant Malagasy species, and of the validity of *M. besoaka*. Herein, we investigate the variation within modern and extinct *Macronycteris* spp. through PCA and non-parametric multivariate analyses (e.g., PERMDISP, PERMANOVA). Living species are sexually dimorphic and display different trends in size and morphological dispersion. When separated by latitude and bioclimate, modern *Macronycteris* spp. were found to differ by location along the western portion of the island. These new assessments validate the recognition of *M. besoaka*, and support the original assertion that it possesses wider molars than modern *Macronycteris* spp. in Madagascar. *Macronycteris besoaka* may have adapted to preying on larger insects, and inhabited a more stable, mesic adapted to surface-terrestrial sister-group, the lacertids (true lizards). Mapping of these trends, and on a time-calibrated phylogenetic tree clearly shows the gradient in cranial bone structure across non-Serpentes lepidosaurs. The extreme condition observed in extinct amphisbaenians, such as the Eocene *Cryptolaemus*, confirms that they likely were fossorial, as previously inferred based on gross morphology. A *Cryptolaemus* from the Miocene had a sampling taken from a surface-terrestrial as well as fossorial snakes, in order to understand the evolution of cranial bone structure in relation to fossoriality across Lepidosauria as a whole.

Grant Information:
EA: German Research Council (DFG AM 517/1-1)
RE: Studienstiftung des deutschen Volkes

Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)

**DIAGNOSIS OF THE PRINCIPAL TAXA OF TERTORNITHIDAE (AVES: ACCIPITRIDFORMES), INCLUDING TERTORNIS MILLER 1909 AND ITS SPECIES T. MERRIAMI AND T. WOODBURNENESIS**

ANDERSON, Julia N., University of California, Berkeley, Berkeley, CA, United States of America; STIDHAM, Tom, Chinese Academy of Sciences, Beijing, China; PADIAN, Kevin, University of California Berkeley, Berkeley, CA, United States of America

The teratorns, large condor-like birds of prey, are among the most important discoveries of the Pleistocene La Brea Tar Pit deposits, because their enormous size and their ecological role. The holotype specimen of the first and most abundant teratorn species described, *Tertornis merriami* (UCMP no. 12101), is an isolated partial skull. The family Teratornithidae is diagnosed on four cranial features: the compression and vauling of the beak, the lateral and backward extension of the post-auditory prominences, the reduced, dome-shaped occipital region, and the flatness of the skull. The genus *Tertornis* diagnosed on three autapomorphies: the angular distal portions of the post-auditory prominences, the ellipsoidal shape of the foramen magnum, and the large, fungiform basipterygoid processes. The holotype contains two referred specimens, a partial beak and quadrates, both of which cannot belong to specimen no. 12101. Although a large quantity of referred material has been found since 1909, no post-cranial specimens have been associated with described cranial material. Of the seven species and six genera within Teratornithidae, only two species, *T. merriami* and *T. woodburnensis*, are contained within the holotype genus, *Tertornis*. *Tertornis woodburnensis* is diagnosed on the facies articularis basipterygoidea, a feature present on the holotype of *T. merriami*. Further taxa cannot be referred to *Tertornis* until a full morphometric study of post-cranial material is conducted.

Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM)

**POSTCRANIAL ANATOMY OF THE LUANGWA BASIN CISTECEPHALID (THERAPSIDA, ANOMODONTIA): PHYLOGENETIC AND FUNCTIONAL IMPLICATIONS**

ANGELECKZYK, Kenneth D., Field Museum of Natural History, Chicago, IL, United States of America; ABBOTT, Caroline P., University of Chicago, Chicago, IL, United States of America; LUNGMSUS, Jacqueline K., University of Chicago, Chicago, IL, United States of America; KEATING, Katarina, University of Chicago, Chicago, IL, United States of America

Cistecephalidae is a clade of Lopingian dicynodonts from southern Africa and India whose skulls and postcrania are modified for a fossorial lifestyle. There are four named cistecephalid species, along with a fifth new species from the Lopingian Upper Madumabisa Mudstone Formation of the Luangwa Basin (Zambia), which is currently under description. It is diagnosed by the presence of tusks, a trough on the ventral surface of the vomer, and an interparietal with a pair of dorsal processes that extend onto the skull roof. A newly prepared specimen (NHIC LA826) preserves the skull and mandible, most presacral vertebrae, pectoral girdle, forelimbs, and a distal hindlimb. When combined with other specimens, nearly the entire skeleton of the Luangwa Basin form can be described. Like other cistecephalids, the scapula lacks an acromion process. The dorsal end of the scapula possesses a short, posterior process, although it is not as prominent as in *Kavingasaurus*. The humeral head is well-osseified and weakly set off from the humerus by an incipient neck. The
insertion of *M. subcoracospuscularis* on the humerus is developed into a distinct process. A strong spininator crest is present, and the deltopectoral crest is proportionally the longest of any cistecephalid. The olecranon process of the ulna is large and well ossified, and the manus is robust. Three sacral vertebrae are present. Little of the femur is preserved, but the tibia and fibula are present and complete. Phylogenetic analysis of a matrix including new postcranial data places *Cistecephalus* and the Luangwa Basin species on the stem leading to a clade comprised of *Saurosuchus*, *Cistecephaloides*, and *Kawingasaurus*. *Cistecephalididae* receives strong branch support, however relationships within the clade are weakly supported. The pectoral girdle and forelimb morphology of the Luangwa Basin form are generally consistent with specialization for scratch digging, but differ in detail from *Cistecephalus* and *Kawingasaurus*. The mosaic of functional traits displayed by cistecephalids indicate that a more nuanced approach to their functional morphology and ecology may be warranted.

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Regular Poster Session I (Wednesday, October 9, 2019, 4:15 - 6:15 PM)

**TOWARDS A MORE COST-EFFECTIVE, TRANSPARENT AND OPEN PUBLICATION WORKFLOW: PEER COMMUNITY IN PALEONTOLOGY (PCI PALEO), A COMMUNITY-DRIVEN PEER REVIEW PLATFORM FOR PALEONTOLOGY**

ANQUETIN, Jérémy, Jurassica Museum, Porrentruy, Switzerland; BILLETT, REVIEW PLATFORM FOR PALEONTOLOGY (PCI PALEO), A COMMUNITY-DRIVEN PEER REVIEW PLATFORM FOR PALEONTOLOGY

Over the years, academic publishing has become increasingly costly for users, institutions, funders, and ultimately the taxpayer. Billions of US dollars of new public money are spent every year on subscriptions and article processing charges. Scientists were long blind to these costs, but there is now a growing realization that these are no longer justified. Open Access is also having a profound impact on the landscape of academic publishing, and this is likely to accelerate as funders worldwide issue Open Access mandates. Finally, science in general is facing a confidence crisis in which the lack of transparency of the peer review process and the over-reliance on perceived impact of research results undoubtedly have a responsibility.

A more transparent, completely open access, and cost-effective academic publishing system is now possible thanks to modern digital technologies. Preprints have more recently penetrated the field of biological sciences, including paleontology, but some justifiably criticize their non-peer-reviewed status.

The peer review process is currently managed by journals, but it is in fact a voluntary service provided by the community. A more transparent and cost-effective evaluation system can be organized by decoupling peer review from publishing. Peer Community in Paleontology (PCI Paleo) is a non-profit, community-driven peer review platform backed up by an international Managing Board and a growing group of editors. Peer review at PCI Paleo is voluntary service provided by the community. A more transparent and cost-effective academic publishing system is now possible thanks to modern digital technologies.

Grant Information:
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Technical Session X (Friday, October 11, 2019, 9:30 AM)

**NEW FINS OR OLD FINS? SKULL AND PECTORAL GIRDLE OF EARLY TRIASSIC ‘PERLEIDUS’ WOODWARDI REVISITED USING μCT**

ARGYRIOU, Thodoris, Museum National d'Histoire Naturelle, Paris, France; ROMANO, Carlo, Palaeontological Institute and Museum, University of Zurich, Zürich, Switzerland

Despite decades of research, the deep-time origins and ancestral morphologies of modern actinopterygians remain contentious. Little is known about the endoskeleton of late Paleozoic-Triassic taxa being particularly fluid with respect to the actinopterygian crown group. Lack of data on the endoskeleton of important fossil groups, and a disjunction among phylogenetic matrices attests at resolving different aspects of the actinopterygian tree. Yet, recent research has cast doubts not only on their evolutionary affinities, but also their monophyly, though no stable phylogenetic alternatives have been provided. Based on previously undescribed material in museum collections in Paris and Zurich, we re-appraise *Perleidus* *woodwardi*, from the early Olenekian (Early Triassic) of Spitsbergen. Exquisitely preserved exoskeletons provide novel data on the ossus constituents of the ethmoid region, and the anatomy of the tail fin, which is now shown to lack obvious epaxial rays. In addition, using μCT, we studied a recently collected, three-dimensionally preserved cranium and pectoral girdle, which revealed a wealth of phylogenetically important information. The braincase and endoskeleton of *P*. *woodwardi* closely resemble those of *Australosomus*, with the presence of a posteriorly elongate parapinephoid in the former being a notable difference between the two. Contrasting primitive actinopterygians, *P*. *woodwardi* shows an increased separation between maxilla and palate, which are more in register as connected by a posterolateral palatal process. Uniquely amongst actinopterygians, *P*. *woodwardi* exhibits perforate anterior pharyngobranchials. The pectoral girdle and fin of *P*. *woodwardi* is unique combining morphological and derived characters, including: an anterodorsally–anterolaterally expanding coracid arch; a ventral coracid ridge; the lack of anterodorsal, or posterodorsal coracid processes; and the presence of a pyropertamid fused with the first ray. Our study of *Perleidus* acts as a vehicle for greatly expanding existing phylogenetic matrices, and re-evaluating traditionally
used characters, like those pertaining to the maxilla and the pectoral girdle. Furthermore, we discuss the potential of testing the morphology and proposed crown group affinities of this salient lineage of Triassic ray-fins within a more informed phylogenetic context.

Grant Information: P2ZHP3_184216 SNF early mobility grant to Thodoris Argyriou

Romer Prize Session (Thursday, October 10, 2019, 11:30 AM)

INHERENT DIETARY FLEXIBILITY WAS KEY TO THE EVOLUTIONARY SUCCESS OF KANGAROOS

ARMAN, Samuel D., Museum and Art Gallery of the Northern Territory, Alice Springs, Australia

Kangaroos and kin (Macropodidae) diversified through the later Neogene, becoming the Australian equivalent of ungulates elsewhere. Differences in craniodental morphology between clades have long suggested that diet was an important determinant of observed diversification and extinction patterns. Previous morphological work has suggested that kangaroos radiated following the late Paleocene expansion of grasslands and arid shrublands, culminating in a dietary dichotomy where macropodines became mostly grazers and shenurines largely browsers. Morphology, though, only points to what an animal may be adapted to eat, rather than actual diet. One means of inferring the diet of individuals is dental microwear texture analysis, which I applied here to further elucidate dietary patterns in kangaroos. In doing so I address a number of technical challenges, ultimately refining microwear methodologies with applications well beyond kangaroos. A multi-taxan dataset was used to appraise how dietary change through the Neogene and to map dietary variation within a diverse assemblage from the middle Paleocene, the interval during which kangaroos diversity peaked. Microwear trends from the early Miocene indicate predominantly browsing diets across numerous clades until the late Paleocene, during which grass becomes a significant dietary component, as reflected by prior studies of dental morphology and macrowear patterns. phylogenetic microwear data show that the shenurine-macropodine browser-grazer dichotomy is oversimplified. Both groups consume a mix of browse and grass, though differences are evident between species, with some more strict browsers and others mixed feeders. When combined with morphological and stable-isotopic evidence, specialist diets are revealed for a number of species. Moreover, some species clearly shifted diets through time. The current sum of evidence suggests that dietary flexibility allowed kangaroos to adapt to changes in vegetation over both the short and long term. Craniodental morphology defines the endpoints of dietary adaptation; actual diet is more linked to availability of foods. One implication is that it is highly unlikely that the reduction of any single vegetation type in the late Pleistocene is more linked to availability of foods. One implication is that it is highly unlikely that the reduction of any single vegetation type in the late Pleistocene is unlikely to have resulted in the continent-wide extinction of the diverse shenurine radiation.

Grant Information: Funding was provided by a Flinders University Research Scholarship

Regular Poster Session I (Wednesday, October 9, 2019, 4:15 - 6:15 PM)

P4 SIZE VERSUS SHAPE IN DISCRIMINATING SPECIES OF MEOGLAIAULAX (MAMMALIA, MULTITUBERCULATA): DOES SIZE MATTER?

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Our understanding of North American Late Cretaceous and Paleocene mammalian faunas is based in large part on the taxonomic identification of poorly preserved fossils, most often incomplete jaws and teeth. Multituberculates—although often the most abundantly represented mammals in any given fauna—are notoriously difficult to identify, particularly in fossil assemblages where they are frequently represented by isolated teeth. Historically, the most useful tool for discriminating species of multituberculates has been the blade-like lower fourth premolar (p4). The size, lateral profile, and morphological detail of p4s have been used not only for recognizing multituberculate taxa, but also in better understanding multituberculate feeding biomechanics, in assessing their paleoecology, and in reconstructing their phylogeny. A recent analysis of co-occurring species of the neoplagiaulacid Mesodoma concluded that size more reliably identified individual p4s to species than did shape alone; based on these results, the study further concluded that all species of Mesodoma may be better discriminated on the basis of p4 size. In order to test this hypothesis, we replicated the study, but supplemented the sample with specimens of other species of Mesodoma, including several from the Judithian of North America, as well as the Paleocene species Mesodoma eurynome. Further, we examined the fidelity of discrimination of shape over size among multituberculate genera with the addition of p4s from several Paleocene species of Neoplagiaulax. Size assessment included principal component analysis (PCA) of p4 lateral profiles (centroid included) and PCA using a set of three linear measurements of the diagonal typically used in species identification (height, length, length1). Shape was assessed using PCA of p4 lateral profiles (centroid excluded). All data sets were analyzed using canonical variate analysis (CVA) to determine discrimination accuracy for both size versus shape analysis. Our preliminary results indicate that size alone may be important in distinguishing multituberculate genera, but shape and size may provide similar levels of accuracy at the species level. These findings suggest that a correct taxonomic referral of multituberculate p4s could be principled based on both shape and size, depending on the level of taxonomic resolution required in a given study.

Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM)

A NEW SPECIES OF PARATOMARCTUS (CARNIVORA, CANIDAE) FROM THE MIDDLE MIocene OF MONTANA

ATWATER, Amy L., Montana State University, Bozeman, MT, United States of America; WANG, Xiaoming, Natural History Museum of Los Angeles County, Los Angeles, CA, United States of America; MAKOVICKY, Peter, The Field Museum, Chicago, IL, United States of America; HANNEMAN, Debra L., Whitehill Geogroup, Inc., Whitehill, MT, United States of America; STOCKLI, Daniel, University of Texas at Austin, Austin, TX, United States of America

Anceney is a middle Miocene fossil locality in southwest Montana that has yielded a range of taxa characteristic of the Barstovian North American Land Mammal Age (NALMA). Herein we describe a new species of Paratomarctus (Canivora, Canidae, Borophaginae) from Anceney and constrain the absolute age of the Anceney locality using detrital zircon U-Pb maximum depositional age analysis. The new species of Paratomarctus, MOR 8673, is represented by a complete skull and mandible. This genus in the Borophagina subtribe, and as such this new species shares the following derived character: dorsally enlarged frontal sinus and the absence of a tubular auditory meatus. Phylogenetic analyses place MOR 8673 in the Paratomarctus clade. MOR 8673 has premolars that are uniformly reduced, an autapomorphy of this clade. The new species is distinguished from the two previously recognized species of Paratomarctus (P. temerarius and P. eutus) by its relatively greater height of the ramus of the lower jaw and by the larger size in most cranial and dental measurements. It is distinguished from P. temerarius in having a moderately widened palate and from P. eutus by lacking a symphyseal flange on the ramus. Despite the Barstovian character of the mammalian fauna, the absolute age of the Anceney locality has not been previously determined. Sixty-eight zircon grains were collected from a tuffaceous sandstone unit that overlies the strata that contained MOR 8673 for U-Pb ages and were analyzed with laser ablation inductively coupled plasma mass spectrometry. Our detrital zircon U-Pb maximum depositional age analysis yields an age of 15.31 +/- 0.24 Ma. The new species and absolute age presented here provide resolution for the age of the fossil-bearing Anceney locality, as well as contributing a better characterization of the early Barstovian NALMA on a broader, continental level.

Technical Session II (Wednesday, October 9, 2019, 10:15 AM)

PALEOHISTOLOGY OF A NEW ORODROMINE FROM THE UPPER Cretaceous (Cenomanian) MUSENTUCHIT MEMBER OF THE CEDAR MOUNTAIN FORMATION, UTAH: HISTOLOGICAL IMPLICATIONS FOR BURROWING BEHAVIOR

AVRAHAMI, Haviy M., North Carolina State University, Raleigh, NC, United States of America; MCVICKER, Patrick, The Field Museum, Chicago, IL, United States of America; ZANNO, Lindsay, North Carolina Museum of Natural Sciences, Raleigh, NC, United States of America

Orodromaeinae is a clade of neornithischian dinosaurs known from Aptian to Campanian deposits of western North America and Asia. Exceptional preservation of the orodromine Orzyctodromus within preserved burrow structures coupled with gross anatomical traits linked to digging behavior, suggest that fossoriality may have characterized most if not all orodromines. The recent discovery of a new orodromine from the Mussenacht Member of the Cedar Mountain Formation, Utah, raises intriguing questions about fossoriality in this species. At least four individuals of different size classes and presumably varied ontogenetic stages were recovered from a single locality. Two of these individuals are represented by partially articulated, tightly overlapping skeletons compacted into a square meter, suggesting the possibility of cohabitation within a burrow structure; however, no
Sedimentological evidence is preserved. Given the rarity of vertebrate burrow by fibrolamellar bone and exhibits a small amount of CCCB localized near the endostal margin. In contrast, regions of the largest femur (NCSM 33545, 11.6 cm long) derives from a juvenile; it is highly vascularized with a cortex dominated other skeletal elements.

Preparers’ Session (Thursday, October 10, 2019, 3:30 PM)

PREPARATION OF INDIURATED CAVE DEPOSITS FROM BARROW ISLAND, WESTERN AUSTRALIA

BADER, Kenneth S., University of Texas at Austin, Austin, TX, United States of America; WAGNER, Deborah E., University of Texas at Austin, Austin, TX, United States of America; COLBERT, Matthew W., University of Texas at Austin, Austin, TX, United States of America; LUNDELIUS, Ernest L., University of Texas at Austin, Austin, TX, United States of America

In 1995, E. L. Lundeilius, A. Baynes, and K. Aplin traveled to Barrow Island, Western Australia, to prospect the abundant Plio-Pleistocene fissure-fill deposits in the Miocene Trealla Limestone for vertebrate fossils. One fissure-fill, labeled Y1, is a breccia consisting of limestone clasts within a calcite-cemented red siltstone. Abundant microvertebrates remain present in the siltstone and visible on the surface of the fill. During excavation, this deposit was broken into cobble- to boulder-sized blocks and shipped to The University of Texas at Austin for preparation. Initial mechanical and chemical preparation proved to be time-consuming and challenging. Difficulties included poor separation between soft bone and hard matrix, high density of overlapping bone fragments, and calcite infilling of bones that reacted strongly with acid. As a result, the project was temporarily postponed.

The project was revisited after advances in high-resolution X-ray CT scanning (HRXCT) allowed for the assessment of individual blocks of matrix for mechanical preparation. Two scans were performed on a block of matrix: a lower resolution data set of the entire block (voxel size = 0.1061 mm), and a higher-resolution scan (voxel size = 0.0219 mm) focusing on two tooth-bearing elements observed in the lower resolution data. The calcite-cemented matrix of the block has similar X-ray attenuation to preserved enamel on teeth, but is considerably more dense than bone. Nevertheless, the scans reveal abundant bone throughout the sample, except within large clasts presumed to be derived from the cave walls. The higher resolution data reveal two mandibles representing a marsupial and a rodent, as well as isolated teeth and other skeletal elements.

Dental segmentation of the mandibles shows extensively fractured bone, suggesting additional physical preparation of the bone may not be advisable. However, due to the inability of mechanical separation of the enamel from the matrix, mechanical preparation of the teeth is necessary for identification. Experiments with chemical preparation were yet inconclusive, therefore fine-detailed micro-preparation was completed with a sharp carbide needle in a pinvice under high magnification using HRXCT as a roadmap. These results underscore the utility of CT data for both identifying candidates for mechanical preparation and for documenting the distribution and abundance of fossils in samples that are otherwise extremely difficult to physically prepare.

Technical Session XI (Friday, October 11, 2019, 10:45 AM)

LANDSCAPE PROCESSES AND DIVERSITY DYNAMICS OF NORTH AMERICAN MAMMALS

BADGLEY, Catherine, University of Michigan, Ann Arbor, MI, United States of America; SMILEY, Tara, Indiana University, Bloomington, IN, United States of America; LOUGHEINEY, Katherine M., University of Michigan, Ann Arbor, MI, United States of America

Mountain ranges are home to biodiversity hotspots for many kinds of plants and animals today. Living mountains show us how a topographic diversity gradient on all of the ice-free continents. However, the fossil record presents a different picture. In the North American record, mammal diversity over the past 30 Myr was often higher on the Great Plains than in the intermontane west. Notably, the topographic diversity gradient was high in the Middle Miocene during an interval of global warming and rapid tectonic extension in the Basin and Range. Similar to today, nearly twice as many mammal species inhabited the Basin and Range as the Great Plains at 15 Ma. We attempted to disentangle the potential interacting influences of tectonic activity, climate change, and basin sediment accumulation on the record of mammal diversity in western North America. We used the PyRate program for Bayesian modeling of macroevolutionary rates to infer origination, extinction and preservation rates from rodent fossil-occurrence data compiled in the MioMap database. We used a geophysical model of tectonic activity to estimate changes in area, elevation, and barriers to dispersal; the marine global temperature record; and basin-fill records to evaluate whether diversification rates were influenced by tectonic, climatic, or preservation history. We found high rates of origination (speciation, immigration) from 20 to 15 Ma and low, variable extinction (true extinction, range shift) rates over the Neogene. Using the multivariate birth-death model implemented in PyRate, origination rates were positively correlated with temperature. The number of fossiliferous sedimentary units in the Basin and Range increased steadily between 25 and 10 Ma, implying that the timing of basin fill was not the major control on the record of species richness across the region. These results suggest that the dominant drivers of macroevolutionary dynamics changed over time. Tectonic extension generated a pulse of origination in the Middle Miocene, whereas global cooling at the end of the Miocene Climatic Optimum caused a loss of mammal species in the Basin and Range as species richness rose on the Great Plains. The integration of dynamic landscape and climate history with diversification processes expands our understanding of interactions between landscape and life today and in the past. The fossil record is critically important in revealing different biogeographic patterns than those of today.

Grant Information:
We acknowledge funding from the U.S. National Science Foundation (Research Coordination Network Program and Integrated Earth System Program).

Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM)

CHARACTERIZING MESOCARNIVORE DISTRIBUTIONS AT RANCHO LA BREA

BALISI, Mairin, Natural History Museum of Los Angeles County, Los Angeles, CA, United States of America; BLOIS, Jessica, University of California at Merced, Merced, CA, United States of America; FARRELL, Aisling, Natural History Museum of Los Angeles County, Los Angeles, CA, United States of America; TAKEUCHI, Gary, Natural History Museum of Los Angeles County, Los Angeles, CA, United States of America; LINDSEY, Emily, Natural History Museum of Los Angeles County, Los Angeles, CA, United States of America

Major environmental disturbances may precipitate the rise of novel communities. This was seen at the end of the last Ice Age following the megafaunal extinctions, which on most continents occurred during a time of climatic change and human impacts. As the large carnivores and their large prey disappeared, so did the interactions that likely exerted cascading trophic effects on ecological communities. Most carnivores today are of small to medium body size: mesocarnivores. North American mesocarnivores before and after the end-Pleistocene present a natural laboratory to track the effects of large-scale disturbance on a faunal community. In the first stage of a three-year project to assess mesocarnivore assemblages from pre- to post-disturbance, we surveyed fossil mesocarnivores preserved at the Rancho La Brea (RLB) asphalt seeps in Los Angeles, southern California, U.S.A. While RLB is known for trapping megafauna, the asphalt also ensnared smaller carnivores, which we comprehensively evaluate here for the first time.

Taphonomic histories likely differed between smaller and larger mammals, as did historical practices of excavation, collection, and curation. Excluding coyotes, five mesocarnivore species are represented by >10 individuals at RLB: badger (Taxidea taxus, minimum number of individuals (MNI) = 20), bobcat (Lynx rufus, MNI = 13), grey fox (Urocyon cinereoargenteus, MNI = 23), striped skunk (Mephitis mephitis, MNI = 37), and weasels (Mustela spp., MNI = 22). These species were found in 33 deposits (“pits”) with dates spanning at least 44,650–5,270 radiocarbon years before present. Five deposits each have yielded >100 identified mesocarnivore specimens. All mesocarnivore-bearing deposits have produced bighorn, grey fox, and striped skunk. Weasels occur mainly in deposits that have undergone systematic digital separation of the enamel from the matrix, mechanical preparation and for documenting the distribution and abundance of fossils in samples that are otherwise extremely difficult to physically prepare.
excavation (Pit 91, Project 23), suggesting that their small body size hindered recovery in earlier mega fauna-focused excavations. About one-fifth of mesocarnivore specimens are juvenile, on par with the proportion of juvenile individuals for megafaunal carnivores. Two hundred mustelid specimens are unidentified to species or genus, necessitating morphometric identification. Racoonon (Procyon), ringtail (Bassariscus), and spotted skunk (Spilogale) also are present but, like weasels, tend to be from systematically excavated deposits. Future analyses will develop radiocarbon chronologies and stable-isotope and morphological data in order to quantify mesocarnivore ecological response to Late Pleistocene disturbance.

Grant Information:
This work is funded by a National Science Foundation Postdoctoral Research Fellowship in Biology, award #1812301, to MB.

Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)
THE BASAL SAUROPODOMORPH THECODONTOSAURUS FROM THE LATE TRIASSIC OF BRITAIN: OSTEONEURAL RE-DESCRIPTION, LIMB MUSCULATURE RECONSTRUCTION AND LOCOMOTION
BALLELL, Antonio, University of Bristol, Bristol, United Kingdom; RAYFIELD, Emily J., University of Bristol, Bristol, United Kingdom; BENTON, Michael J., University of Bristol, Bristol, United Kingdom
Thecodontosaurus was the first sauropodomorph dinosaur ever named and one of the most basal members of this clade, making it crucial for the understanding of the early evolution of the group. Its fossils have been found in different fissure fill localities of southwestern Britain, although the holotype and the material that served to describe the type species T. antiquus come from the early Rhaetian deposits of Durhams Down in Bristol, United Kingdom. Specimens found in the south Wales locality of Pant-y-flynnon were assigned to a new species, T. caducus, that was later given its own genus, Pantydraco. Here, we describe for the first time the numerous and well-preserved remains from Tythertong, Southwestern England, found in 1975. We find these specimens can be assigned to T. antiquus. The osteology of Thecodontosaurus is updated and new anatomical information of previously poorly preserved or missing bones is added. We provide a revised diagnosis of the species and discuss its phylogenetic position. Comparing the anatomy of Thecodontosaurus and Pantydraco, we propose that the possibility of the latter being a juvenile of the former cannot be ruled out. We also reconstruct limb muscle attachment sites from osteological correlates and inferences based on the extant phylogenetic bracket. From this we find that Thecodontosaurus possessed a plesiomorphic limb musculature arrangement for sauropodomorphs. Muscle attachment sites and functional morphology of the limb bones indicate that it was a biped with crouched hindlimbs and partially supinated forelimbs. Further biomechanical investigation is required to test whether it was an obligate or facultative biped, and more detailed aspects of locomotion.

Grant Information:
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Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)
STABLE ISOTOPIC SIGNATURES OF FOSSILISED RODENT TEETH: FAUNAL RESPONSE TO CLIMATE CHANGE IN SOUTH-EASTERN AUSTRALIA DURING THE LATE QUATERNARY
BAMPTON, Tiah L., The University of Adelaide, Adelaide, Australia; TYLER, Jonathan, The University of Adelaide, Adelaide, Australia; MCIKENERY, Francesca, The University of Adelaide, Adelaide, Australia; REED, Elizabeth, The University of Adelaide, Adelaide, Australia
An understanding of how past climate and environmental change has influenced faunal communities over time is important for understanding how future climate change may affect ecosystems. Stable isotopic analysis of bioapatite from fossilised mammalian tooth material is a well-established proxy for reconstructing past climate and vegetation. The use of small mammals, in particular rodents, has been overlooked in the past for such studies. Owl-accumulated deposits preserved in caves in the Naracoorte Caves World Heritage Area (NCWHA), yield abundant assemblages of fossilised rodent remains providing large samples from which a temporal scale of climate and vegetation change can be reconstructed. In this study, stable carbon (δ13C) and oxygen (δ18O) isotopic composition of bioapatite from the incisors of three Australian rodent species was used as a proxy to reconstruct the paleoclimate and paleovegetation of the Naracoorte region. δ13C and δ18O analyses were performed on crushed incisors of three species of Pseudomys (P. auritus, P. australis and P. shortridgei) across the upper 27 sedimentary layers from a palaeontological excavation in Blanche Cave (NCWHA). The layers were assigned into climatic-stratigraphic units, preglaciation (layers 27-25, 9 to 35 ka), early-glaciation (layers 24-20, 32 to 25 ka), Last Glacial Maximum (layers 19-15, 22 to 19 ka) and deglaciation (layers 13-1, 17 to 14 ka). Relative abundances and isotopic values for the three species were calculated for each unit. The carbonate bound component of the bioapatite was analysed for δ13C and δ18O, as well as the additional analysis of phosphate bound oxygen (δ18OPho) using isotope ratio mass spectrometry. Isotopic signatures from δ13C and δ18O were used to reconstruct paleoclimate and paleovegetation over the four climatic-stratigraphic units, which were compared to existing paleoclimate studies. Through these units there were changes in the dominance between C3 and C4 plants, as well as changes in the water regime, form cool, wet to warm, dry environments.

As rodents are commonly abundant in fossil deposits globally, they have the potential of being used to determine climatic and vegetation change associated with extinction events, such as the megafauna extinction in Australia. This study also has the potential to extend to larger mammals, such as the megafauna, to understand how large mammal communities have reacted to changes in climate and vegetation.

Grant Information:
This study was funded by the University of Adelaide, Department of Earth Sciences.

Technical Session XV (Saturday, October 12, 2019, 8:15 AM)
HIGH-DENSITY MORPHOMETRIC ANALYSIS OF MACROEVOLUTION AND PHENOTYPIC INTEGRATION OF THE ANURAN (FROG) CRANIUM
Anurans (frogs) are the most speciose amphibian clade (numbering over 7000 species), and they exhibit astonishing cranial diversity, creating a significant challenge for quantifying cranial morphology across the clade. Consequently, studies of morphological evolution and modularity (the division of a structure into subsets of integrated/correlated traits) are limited in taxonomic breadth, or density of shape data, for frogs. Here we quantify anuran cranial morphology using high-density semilandmarks for 173 anuran species sampling every extant anuran family and including the Eocene species Thaumastosaurus gezi. We define 19 cranial regions with 58 landmarks, 59 curves, and 527 surface points. The complex morphology of the frog skull is thus represented by a total of 995 (semi)landmarks, making this the most comprehensive dataset of anuran cranial morphology to date, in terms of both taxonomic sampling and density of shape data. With these shape data we identify the best-supported modular structure using maximum likelihood (‘sPLM’) and Covariance Ratio analysis. We investigate phylogenetic, allometric and ecological influences on cranial morphology, as well as determining the disparity and evolutionary rate of each cranial module. Anuran crania are highly modular and more integrated posteriorly, with highest support for a 13-module model including multi-region ‘suspensorium’ and ‘occipital’ modules. This pattern is strikingly similar to the pattern of integration identified in caecilians, suggesting conservation of modularity across these two amphibian clades. Anuran crania exhibit significant influences of phylogeny (Kwas = 0.66, p = 1e-04), evolutionary allometry (R2 = 0.12, p = 1e-04), and ecology (R2 = 0.16, p = 0.003). Fossorial and aquatic species occupy distinct areas of cranial morphospace, with fossorial species associated with dorsoventrally taller skulls. Of the 13 cranial modules, the vertical sphenethmoid is the most disparate, and the paraphenidium the least (Procrustes variance = 1.95 x10-5, 6.00 x10-6 respectively), with earlier ossifying bones generally less disparate. Evolutionary rate is fastest in the stapes and suspensorium modules, and lowest in the paraphenidium (srsab = 5.99e-08, 5.26e-08, 1.76e-08 respectively). We find no significant relationship between integration and disparity (R2 = 0.05, p = 0.48), or between integration and rate (R2 = 0.02, p = 0.68), suggesting strong integration variably promotes or constrains (or has little effect on) morphological evolution of anuran cranial modules.

Grant Information:
This research was funded through ERC grant STG-2014-637171 to Anjali Goswami
CVA shows that bird wings can be accurately classified by clade 82.3% of the aspect ratio wings, though a few converge with lower aspect ratio wings. The Technical Session X (Friday, October 11, 2019, 11:30 AM) very recent trend in evolution.

We collected two-dimensional geometric morphometric data from a diverse group of 138 “water bird” wings. The wing and dorsal covert outlines were digitized using thirteen homologous landmarks and 300 semi-landmarks. We then used a principle component analysis (PCA) to visualize the data and a canonical variate analysis (CVA) to determine how well the data separates into groups by foraging behavior and then by clade. Overall, the wings plot along axes featuring aspect ratio and wing-tip shape – low aspect ratio wings with rounded tips on one side of the plot, and high aspect ratio wings with pointed tips on the opposite end. Some behaviors like stalkers and plunge divers have tight clusters, while other behaviors like low aspect ratio wings with rounded tips on one side of the plot, and high aspect ratio wings with pointed tips on the opposite end. Some behaviors like stalkers and plunge divers have tight clusters, while other behaviors like surface diving and probing have a wide diversity of wing shape. Clades cluster out much more clearly. Charadriformes, for example, have generally higher aspect ratio wings, though a few converge with lower aspect ratio wings. The CVA shows that bird wings can be accurately classified by clade 82.3% of the time, while classification by behavior is only 65.7% accurate. These results suggest that wing shape is more diverse in terms of foraging behavior than it is in terms of clade, and that other factors may be at play with regards to wing shape. Combined with other studies indicating bird beak shape is not as influenced by ecology as expected, this work emphasizes the importance of evolutionary history in constraining form and divergence in function is a very recent trend in evolution.

Technical Session X (Friday, October 11, 2019, 11:30 AM) OUTSTANDING MORPHOLOGY OF SOME MESOZOIC GONDWANAN FISH CONFLICTING PREVIOUS TAXONOMIC AND PHYLGENETIC INTERPRETATIONS.

Outstanding morphology of some Mesozoic Gondwanan fish conflicting previous taxonomic and phylogenetic interpretations.

BEAN, Lynne B., Australian National University, Canberra, Australia; ARRATIA, Glória, Kansas University, Lawrence, KS, United States of America

Waldmannichthys koonwarri is an Aptian freshwater fish from the Koonwarra Fossil Beds in Victoria, (Australia) and Cavenderichthys talbragarensis is also a freshwater fish from the Tithonian Talbragar Fossil Fish Bed in New South Wales, (Australia). Recently, these two species, together with Luisiella feruglioi from the Oxfordian-Tithonian of Patagonia, (Argentina), were included in a new teleostean family, Luisiellidae. This new family was interpreted as a stem teleost group, closer to Leptocephalosteidae than to the crown-group Teleostei. Examination of 46 previously undescribed specimens of W. koonwarri, from Museum Victoria, has resulted in the discovery of new morphological characters, and the special configuration of the jaws and the position of the quadrate-mandibular articulation; the special vertebral pattern at the level of the abdominal/caudal regions; a stegural-like unvascular in the caudal skeleton; and the structure of the scales. This inspired a re-examination of the morphology of Cavenderichthys and Luisiella. Hence the systematic position of the Gondwanan taxon was re-evaluated using a pre-existing data matrix including about 240 characters and 57 taxa. The new results give a very different scenario, with the three taxa now included in the crown-group Teleostei. Luisiellidae is restricted to its type-species, L. feruglioi. In contrast, the two Australian species cluster together with the Late Jurassic European genera Leptocephalosteus and Orthogonikleithrus emphasizing the role of the Tethys Ocean and the position of South America and Australia at the time of the break-up of Gondwana.

Grant Information: LB is supported by the Australian Government Research Training Program.

Symposium: Origin of a Sunburnt Country (Saturday, October 12, 2019, 8:00 AM) MACROEVOLUTIONARY DYNAMICS OF SOUTH AMERICA AND AUSTRALIAN FAUNIVOROUS MARSUPIALS DURING THE NEOGENE.

BECK, Robin M., University of Salford, Manchester, United Kingdom; ENGELMAN, Russell K., Case Western Reserve University, Chagrin Falls, OH, United States of America; TRAUVILLON, Kenny, Western Australian Museum, Welshpool, WA, Australia.

South America and Australia are the only major landmasses where the dominant faunivorous mammals for most of the Cenozoic were metatherians (marsupials and their fossil relatives), most notably microbiotherians, paucituberculatans, sparassodonts and didelphimorphians in South America, and peramelemorphians and dasyuromorphians (dasyurids and thylacinids) in Australia. There has been considerable controversy as to the extent to which these clades competed with each other and filled similar ecological niches. Analyses of the diversification of extant lineages provides only limited insight into the evolution of these clades, because the known modern diversity of Microbiotheria (one species), Paucituberculata (seven species) and Thylacinidae (one species) is reliequed compared to their known fossil diversity, and Sparassodonta is entirely extinct. Here we use a combination of phylogenetic analyses including fossil and extant taxa (including the first tip-dating analyses of microbiotherians, paucituberculatans and sparassodonts using Bayesian morphological clock models), fossil occurrence data, and quantitative analyses of body size and tooth shape to infer the macroevolutionary dynamics of these clades during the Neogene. There is support for broadly synchronous faunal turnover among these groups during the middle-to-late Miocene in both South America and Australia, suggesting a common abiotic (probably climatic) driver. There appears to be a distinct lag of several million years before didelphids and dasyurids evolved to fill the niche of small mammals.
medium-sized (>300 g) predatory niches, again suggesting passive rather than active replacement. Dental morphology within these clades shows clear phylogenetic signal, making ecomorphological comparisons difficult, but dasyurids and thyliacids overlap in dental morphospace, suggesting that they are indeed ecologically similar, and early Miocene peramelemorphians fall between modern peramelemorphians and dasyuromorphians.

Grant Information: Australian Research Council (DE120100957)
Santander Travel Grant

Regular Poster Session I (Wednesday, October 9, 2019, 4:15 - 6:15 PM)

BONE PATHOLOGIES IN THE EARLY CRETACEOUS THERIZINOSAURIAN FALCARIUS UTAHENSIS

BEGUESSE, Kyla A., North Carolina Museum of Natural Sciences, Raleigh, NC, United States of America; CANOVILLE, Aurore, North Carolina Museum of Natural Sciences, Raleigh, NC, United States of America; HERZOG, Lisa L., North Carolina Museum of Natural Sciences, Raleigh, NC, United States of America; ZANNO, Lindsay, North Carolina Museum of Natural Sciences, Raleigh, NC, United States of America

Paleopathologies provide key information on evolution and epidemiology of disease, and behavior in extinct animals. We describe osteopathologies observed in the right metatarsus II (NCSC 27412) and left humerus (UMNH VP 14661) of the early diverging therizinosaurian, Falcarius utahensis, represented from the local bimodal bonebed in the Lower Cretaceous Cedar Mountain Formation of eastern Utah. The two specimens were collected approximately 52 meters apart, making it unlikely the metatarsus and humerus are from the same individual. Morphologic diagnoses are based on microscopic and histologic examination of the fossilized lesions, and comparative pattern recognition analysis of histomorphic features in vertebrate pathologic processes. Macroscopically, both the right metatarsus II and left humerus exhibit irregular nearly circumferential bulbous expansion in the mid-diaphyseal region. Histologic lesions in the right metatarsus II are most consistent with healing fractures stabilized by a chronic callus encasing the fracture ends, thereby inhibiting the normal development of a callus. Histomorphic features in the metatarsal fossilized lesion provide evidence that this was a complicated fracture in the pes of a subadult individual with delayed healing. Histologic examination of the left humerus reveals lesions most consistent with chronic osteomyelitis with abscess/microabscess formation, osteonecrosis and lysis, and both subperiosteal and endosteal reactive bone formation. The pattern and distribution of these lesions are suggestive of an infectious etiology that likely initiated in the corticomedullary junction and extended to the subperiosteal periphery of the humerus. A minimum estimation of 300 individuals are represented in this Lower Cretaceous Cedar Mountain Formation, and preliminary analysis of the bonebed suggests the individuals succumbed to a mass mortality event. Further research is required to evaluate the prevalence of additional osteopathologies, and if these pathologies have any correlation with the mass mortality event.

Technical Session VI (Thursday, October 10, 2019, 11:15 AM)

NAKALIPITHECUS AND HOMININE ORIGINS

BEGUN, David R., University of Toronto, Toronto, ON, Canada

Several samples of the late Miocene fossil apes from Africa are said to “fill the gap” both chronologically and phylogenetically between middle Miocene African stem hominids and the earliest hominins. These samples, attributed to Nakalipithecus, Samburupithecus and Chororapithecus, have been interpreted as having closer affinities with African apes and humans than do Eurasian Miocene apes, despite small samples, poor preservation and no formal cladistic analysis. To test this conclusion, I carried out the first formal morphometric phylogenetic analysis to include Nakalipithecus and other middle and late Miocene apes from Europe and Africa. The data were analyzed using TNT. Character states were unordered. The outgroup was Ekombo from the early Miocene of Kenya. The sample was limited to mandibular and dental remains, given the preservation of Nakalipithecus. The results were incongruential, with low CI and RI values (0.25-0.37) and multiple polytomies. This is not surprising given the restriction to mandibular and dental characters (those available for Nakalipithecus.) However, none of these polytomies support the prevailing hypothesis that Nakalipithecus, Samburupithecus or Chororapithecus are hominins. They fall out as either stem hominids or stem hominoids. The low CI and RI values suggest that the data are insufficient to conclude, despite claims to the contrary, that there is convincing evidence of the presence of hominines in the late Miocene of Africa.

Grant Information: NSERC Grant File Number: RGPIN-2016-06761

Technical Session VII (Thursday, October 10, 2019, 11:45 AM)

TAPHONOMY AND PALEOCOMMUNITY RECONSTRUCTION OF A PTEROSAUR-BEARING FOSSIL ASSEMBLAGE IN THE UPPER TRIASSIC OF ARIZONA

BEHRENSMeyer, Anna K., Smithsonian Institution, Washington, DC, United States of America; WHATELEY, Robin L., Columbia College Chicago, Chicago, IL, United States of America; FITCH, Adam J., University of Wisconsin, Madison, WI, United States of America; PARKER, William, Petrified Forest National Park, Petrified Forest National Park, AZ, United States of America; MCINTIRE, Suzanne, Smithsonian Institution, Washington, DC, United States of America; PRITCHARD, Adam C., Smithsonian Institution, Washington, DC, United States of America; KLIGMAN, Ben, Virginia Tech, Blacksburg, VA, United States of America; CLINE, Richard G., Smithsonian Institution, Washington, DC, United States of America

The paleoecology of pterosaurs and other members of late Triassic vertebrate communities has been inferred primarily using functional anatomy and association with specific environments. The RLW11-56 quarry in the upper Chinle Fm. of Petrified Forest National Park provides new evidence for the ecology of Late Triassic vertebrates. Uranium-Lead dating of detrital zircons from the quarry place its age at 209.16±0.08 Ma, making this the most precise date available for a Triassic pterosaur and associated fauna. Microscopic analyses of matrix blocks has yielded >1300 catalogued specimens, most of which are smaller than 2 cm diameter and represent diverse taxa, body parts, and preservation states. Bones generally are disassociated and fragmentary but include well-preserved, delicate elements. Isolated teeth are abundant, limb elements uncommon, and cranial and dentary elements rare. Remains were buried together in poorly sorted conglomerate that filled a local depression in a small fluvial channel cut into floodplain deposits. The fauna includes: actinopterygian, metoposaur, cheiroleipuran, anuran, phytosaur, aetosaur, Revueltosaurus, pterosaur, stem-archosaur, rhynchocephalian, and theropod, along with possible trilophosaur and cynodont. Notably absent are molluscs and dipnoans, which are common elsewhere in the Chinle Fm., and mammaliforms. Micro-extraction provides an unbiased assemblage that can be used to examine paleocommunity structure and taphonomic history. From geological and taphonomic evidence, we infer that the fossil-bearing unit was formed by a flood that entrained sediment and skeletal debris from the channel bed and deposited it rapidly, with minimal sorting and reworking. The most complete fossils, including partial pterosaur jaw, fish scales, delicate feet, and turtle elements, represent “first cycle” remains that experienced limited taphonomic damage prior to final burial. These were mixed with previously reworked bones and teeth, resulting in some degree of temporal and spatial averaging. However, the identifiable subset of the quarry sample likely represents a relatively short period of time, on the order of years to centuries. The RLW11-56 assemblage shows that pterosaurs, Revueltosaurus, fish, frogs, turtles, and other taxa co-existed in a fluvial ecosystem during the latest Triassic in SW North America. The exceptional variety of teeth, many of which cannot be identified using available aapomorphies, suggest a higher level of functional diversity than most other Chinle Fm. localities.

Grant Information: We thank the Smithsonian’s National Museum of Natural History and NMNH FossilLab, Columbia College Chicago, and the US National Park Service for supporting this research.

Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM)

DIAGNOSTIC EFFICACY OF PUBLISHED MORPHOLOGICAL CHARACTERISTICS OF NORTH AMERICAN SAND LIZARDS

BELL, Christopher J., University of Texas at Austin, Austin, TX, United States of America; SCARPETTA, Simon G., University of Texas at Austin, Austin, TX, United States of America; ANDERSON, Danny, Brown University, Providence, RI, United States of America

We present results of our effort to assess the reliability of published morphological features of the skeleton that reportedly have power to
discriminate among taxa in the monophyletic clade of iguanian lizards colonially known as ‘sand lizards.’ These include species within the genera *Callosaurus*, *Cophosaurus*, *Holbrookia*, and *Uma*. Phylogenetic analyses based on morphology and molecular data recover these taxa as a monophyletic clade that is sister to the horned lizards of the genus *Phrynosoma*, but there is no consensus about relationships among the sand lizard genera. Although there is no currently published fossil record for *Uma*, the other three genera all have a published fossil record. We reviewed the primary literature of the Neogene and Quaternary fossil record for published reports of sand lizards that were identified at least to generic level. We found 32 publications that document the fossil record for the group. Of those, only 12 documented morphological features to support taxonomic identification; the others simply included taxa in a faunal list without meaningful comment. We discretized 15 morphological features so that they could be scored in a matrix format to facilitate ease of comparison among and between specimens and taxa. We then scored morphological features for 114 specimens of sand lizards, representing all four genera and every species in the group. Of those, only 12 documented morphological features to support morphological variation within taxa independent of geographic range. Only one published feature, the shape of the ventrolateral edges of the frontal, consistently allowed identification of *Callosaurus ulbrichti* to the exclusion of the other taxa. No other published features served to discriminate among the taxa. These data emphasize the need for additional morphological work, and especially a search for apomorphic characters, before the late Cenozoic fossil record of North American sand lizards can be reliably interpreted. In our experience, this holds true for other groups of squamates as well, and marks a critical need for additional research on the evolutionary morphology of the group.

Technical Session XIX (Saturday, October 12, 2019, 2:00 PM)

**MID-CRETACEOUS ENDEMICITY OF EASTERN AUSTRALIAN VERTEBRATE FAUNAS**

**BELL,** Phil R., University of New England, Armidale, Australia; **CAMPBONE,** Nicolas E., University of New England, Armidale, Australia; **SMITH,** Elizabeth T., Australian Opal Centre, Lightning Ridge, Australia; **MILAN,** Luke, University of New England, Armidale, Australia

The Cenomanian-aged Griman Creek Formation (GCF) in eastern Australia preserves one of the most diverse vertebrate fossil assemblages from the mid-Cretaceous in eastern Gondwana. The GCF is therefore a crucial, yet largely unexplored, datum for examining paleobiogeographic connections within Australia’s limited Cretaceous terrestrial record and across Gondwana more broadly. To date, vertebrates in the GCF include a diversity of fishes, plesiosaurs, turtles, pterosaurs, crocodylomorphs, ankylosaurians ornithopods, sauropods, theropods (including birds), and mammals. Given this diversity, we ask: how does the inclusion of often-overlooked Australian faunas contribute to our understanding of global paleobiogeography during the Mesozoic? Here we combine non-metric multidimensional scaling (NMDS) and minimum spanning trees to characterise potential connections between 15 Cretaceous (Aptian-Cenomanian) formations from Australia, and South America. The data set includes 257 taxon-level entries of aquatic and terrestrial vertebrates from the Paleobiology Database supplemented by the recent literature. Our analyses were carried out at a high taxonomic resolution (family or above), as high levels of specific endemicity will mask potential connections. However, various taxonomic schemes were tested. Results reveal: 1) high levels of endemicity overall via a significant positive correlation between geographic distances between formations and their faunal dissimilarity (*p*<0.01, *r*<0.001) and 2) strong connectivity between Australian formations to the exclusion of those from Africa and South America. Endemism, especially among Australian faunas (NMDS axis 1), is driven by occurrences of ausstralospherid mammals, certain dinosaurs (ankylosaurs, ornithopods), plesiosaurs, temnospondyls, and certain osteichthysans (albuliforms, crosognathiforms, pachychonform) along with a dearth of many carnivorous dinosaurs (alvarezsaurids, carcharodontosaurids, coelurosaurs), dryolestoid mammals, and polypterus and sphenosuchiform osteichthysans. Our results indicate that, by the mid-Cretaceous, endemicity of Australia’s fauna was established, with East Africa and South America continued to share faunal similarities into the Late Cretaceous. These findings are congruent with current tectonic models, which place the physical break up between West Africa and South America) and East Gondwana (Australia and Indian, Antarctica) in the latest Jurassic.

**Grant Information:**

Funding provided by an Australian Research Council Discovery Early Career Researcher Award to PRB.

Technical Session XV (Saturday, October 12, 2019, 10:15 AM)

**STERNAL EVOLUTION IN SYNPADIDA AND THE ORIGIN OF THE MAMMALIAN STERNUM**

**BENDEL,** Eva-Maria, Museum für Naturkunde, Berlin, Germany; **KAMMERER,** Christian F., North Carolina Museum of Natural Sciences, Raleigh, NC, United States of America; **FROBISCH, Jörg, Museum für Naturkunde, Berlin, Germany

The sternum is a functionally important thoracic bone in extant birds and mammals, where it helps protect the chest cavity and serves as an attachment site for ribs and pectoral muscles. The sternal morphology of mammals is unique among amniotes: a multipartite structure consisting of the anterior manubrium, several sternebrae, and a posterior xiphoid process. Birds and mammals, the sternum is a single keeled element, whereas in other amniotes it is poorly-developed, being cartilaginous or absent entirely in many extant reptiles and rarely preserved in the reptilian fossil record. Because of its poor record outside the mammal crown, the origins and evolution of the mammalian sternum are not well understood. Previously, the earliest record of a multipartite sternum was in the Triassic cynodont *Diademodon*, although problematically, comparable structures are not known in more crownward non-mammalian cynodonts. Here, we provide new insight into mammalian sternal evolution through an analysis of a single specimen and present the first evidence for a mammal-style sternum among Permian synapsids.

In early synapsids (‘pelycosaurs’ and dinoccephalians) there is no evidence for an ossified sternum; its earliest record is in dicynodonts, where it is a single plate-like element. Historically, gorgonopsians were thought to also have a single sternal element. However, our study of postcranial material referable to *Gorgonops* (late Permian) demonstrates that its sternum (attached to a large oval interclavicle) was divided into a larger anterior manubrium and three smaller posterior sternebrae. The metameric sternebrae resemble the configuration seen in Theria, making this the earliest record of a mammal-like sternum and indicating a deep evolutionary origin of this feature. However, there is no evidence it was multipartite in the more crownward Theriodontia. Our examination of numerous well-preserved specimens representing most theropods and cynodonts is likely attributable to the sternum remaining cartilaginous in small taxa and historic poor preservation/preparation.

**Grant Information:**

This research was funded by an Elsä Neumann Scholarship of the State Berlin, Germany, to EMB.

Technical Session XIV (Friday, October 11, 2019, 2:45 PM)

**NEW ICHTHYORNIS SPECIMENS: SHEDDING NEW LIGHT ON MODERN BIRD ORIGINS**

**BENITO,** Juan, University of Bath, Bath, United Kingdom; **BHULLAR,** Bhart-Anjan, Yale University, New Haven, CT, United States of America; **BROHJEN,** David, University of California, Berkeley, United States of America; **WILSON,** Laura E., Fort Hays State University, Hays, KS, United States of America; **FIELD,** Daniel, University of Cambridge, Cambridge, United Kingdom

The origin of crown birds is poorly understood and the study of their early evolution must incorporate data from their closest relatives among Mesozoic stem birds. The postcranial morphology of the Late Cretaceous toothed bird *Ichthyornis dispar* may be more representative of the ancestral condition of crown birds than that of any other known Mesozoic avian, and its study has crucial importance for understanding morphological evolution prior to the great radiation of the avian crown group. Here we present high-resolution scans of new, exquisitely preserved three-dimensional specimens of *Ichthyornis* from the Late Cretaceous of Kansas. These correspond to a partial skeleton from a single individual, more complete and in better condition than the classic material known since the 19th Century. The new material includes a complete sternum and shoulder girdle with evidence of extensive pneumatization. This new skeleton shows certain morphological differences from the classic material, including the absence of some previously proposed autapomorphies of *I. dispar*. Thus, the new material may represent a previously unknown species, or it could indicate that morphological variation within *I. dispar* was greater than previously appreciated.
Phylogenetic analyses incorporating our new morphological data corroborate recent results and recover a grade of predominantly marine taxa close to the origin of crown birds. *I. dispar* is recovered stemward of Hesperornithes and *Laeocolis marshi*, which is recovered as the sister taxon to all crown birds. Additional information on the crownward-most portion of the avian stem group will help confirm these results and provide critical information on the ancestral ecology of the crown bird radiation.

**THE INFRAORBITAL FORAMEN IN CYNODONTS AND MAMMALS: ORIGIN OF WHISKERS AND HOMOLOGY**

BENOIT, Julien, University of the Witwatersrand, Johannesburg, South Africa; RUF, Irina, Senckenberg Forschungsinstitut und Naturmuseum, Frankfurt am Main, Germany; MIYAMAE, Jun, Yale University, New haven, CT, United States of America; FERNANDEZ, Vincent, British Museum of Natural History, London, United Kingdom; RODIGUES, Pablo G., Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil; RUBIDGE, Bruce S., University of the Witwatersrand, Johannesburg, South Africa

In mammals, the infraorbital foramen (IOF) and canal are located in the maxilla rostral and ventral to the orbit and provide a passage for the infraorbital nerve (a branch of the maxillary division of the trigeminal nerve). The infraorbital nerve (ION) ensures sensitivity of the upper teeth and face between the eye and upper lip including facial vibrissae (whiskers). Homology of the IOF across mammals is based on the fact that it gives passage to the ION. In most non-mammalian synapsids the ION is replaced by the maxillary canal, which completely encloses the ION and its branches. Remarkably, the pattern of ramification of the branches of the maxillary canal can be homologised with that of the ION in modern mammals, which strongly supports the idea that the two structures are homologous. In contrast, a conspicuous foramen present below the orbit on the maxillo-lacrimal suture in Probainognathus (the non-mammalian Cynodontia more closely related to mammals than to Therapsida) and early Mammaliaformes (e.g., *Morganucodon*), has in the past been homologised to the ION by most authors. Using μCT-scanning and 3D modelling to reconstruct the evolution of the maxillary canal from the primitive synapsid condition to the modern mammalian condition in Probainognathia, it is here suggested that this foramen did not provide a passage for the ION. According to our observations, this pseudo-IOF might, in fact, have been for the zygomatic nerve and/or a blood vessel. In addition, this study shows that the transition from a maxillary canal to a mammal-like ION was gradual, and that a mammalian ION evolved in the last common ancestor of Probainognathus and more derived cynodonts. This suggests that whisking movements and associated whiskers evolved in the mammalian lineage before the very origin of Mammaliformes, some 241 million years ago.

**GRANT INFORMATION:**

We thank the European Synchrotron Radiation Facility, the Claude Leon Foundation, FAST, the NRF African Origin Platform and DST-NRF Centre of Excellence in Paleosciences.

**EDUCATION AND OUTREACH POSTER SESSION (Wednesday - Saturday, October 9-12, 2019, 14:05 - 16:15 PM)**

**SHARKS’ TEETH, SHELLS AND CITIZEN SCIENCE**

BERNARD, Emma L., The Natural History Museum, London, United Kingdom; WARD, David J., NHM U.K., Orpington, United Kingdom; WARD, Alison, Natural History Museum, London, United Kingdom

Abbey Wood is a famous Early Eocene fossil locality situated in south-east London, U.K. The fossils come from a particularly rich shell lens within the Blackheath Formation. It is mainly composed of broken mollusc shells and flat pebbles and fine sand but does have some perfectly preserved sharks’ teeth and shells along with rare mammal, bird and reptile remains.

The site was first recorded in 1872 when sharks’ teeth and shells were seen in rabbit holes, but not exploited until the 1920’s when two amateur collectors, F. J. Epps and W. J. Marriott, made a large collection from this locality, enlarging the rabbit burrows into a small pit. In 1969 the Tertiary Research Group (TRG) and the Natural History Museum, London (NHMUK) started a series of small annual excavations, mapping the extent of the deposit and extracting the fossils using wet sieving. Since then many significant finds have been made that have been deposited in scientific institutions and resulted in many important scientific papers.

In 2005 the NHMUK expanded the project to allow members of the public to engage with palaeontologists and help sort some of the fossil material. This was done at the Lyme Regis Fossil Festival (LRFF), a large science festival in the U.K. which is held in Dorset every May. The citizen science project which developed was simple. The aim was to explain to members of the public, usually children, the concept of deep time; the process of fossilization; how to identify fossils; why common and scientific names are used and the importance of properly labelled specimens. The most important thing was to pass on our enthusiasm for palaeontology.

During the activity, the participants screen the sediment through different sized sieves, then carefully pick out fossils and identify what they have found using an ID guide. They may keep what they have found, predominately shark and ray teeth and shells if they identify them. If any rare specimens are found, such as mammal remains, the NHMUK gratefully accept them, however the participant is told about the significance of their find. In our experience, they are always pleased to have found something important and many come back to repeat the activity and show off some of their own finds.

Over the last 50 years, approximately 400 people a year are involved in the excavations and since 2005 we have participated at the LRFF where we have engaged with more than 8500 people, sieving just short of 4 tonnes of shell bed.

This year the project was nominated for the prestigious Pal. Ass. Gertrude Elles Award for high quality public engagement in the field of palaeontology.

**GRANT INFORMATION:**


**ENVIRONMENTAL EFFECTS ON BODY SIZE IN LATE CRETACEOUS LAMNIFORM SHARKS FROM THE ENGLISH CHALK: UNLOCKING HIDDEN DATA IN HISTORIC COLLECTIONS TO ADDRESS KEY SCIENTIFIC QUESTIONS.**

BERNARD, Emma L., The Natural History Museum, London, United Kingdom; SINHA, Sinjini, Edmonton, AB, Canada; PEARSON, Wilfrid J., University of Birmingham, Birmingham, United Kingdom; GALLAGHER, Liam T., University of Birmingham, Birmingham, United Kingdom; TWITCHETT, Richard J., Natural History Museum, London, United Kingdom

The environmental effects of global warming, such as higher seawater temperatures and reduced levels of dissolved oxygen in the world’s oceans, are predicted to cause a reduction in the sizes of marine fish, with wide-ranging implications for marine ecosystem structure and function. This hypothesis is mainly based on theoretical considerations and short-term experimental studies on small-bodied echinoderms, such as benthic marine invertebrates. The fossil record of past global change events provides an archive of data that can be used to test this hypothesis in taxa that cannot be studied in vivo, such as sharks and other apex marine predators, and over much longer timescales.

In this study, we analysed size change in Late Cretaceous lamniform sharks from the English Chalk to test whether they became smaller in response to global environmental change during the Cenomanian-Turonian anoxic event (OAE 2) and Cretaceous Thermal Maximum. Due to their cartilaginous skeletons, often only the teeth of sharks are preserved in the fossil record. However, tooth size can be used as a proxy for body size. Shark teeth have been collected from the Chalk Group of England for more than 200 years and the museums of southern England, in particular The Natural History Museum, London, which houses one of the most important collections of Late Cretaceous fish worldwide, contain substantial archives of potential data. Unfortunately, many museum specimens were collected more than 100 years ago and the very sparse stratigraphic data associated with them limits their usefulness. In order to improve this, we extracted nanofossils from the associated matrix of selected specimens with poor stratigraphic control in order to better constrain their relative ages and thus increase our dataset.

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Key morphometric variables were measured from 761 fossil teeth spanning 14 lamniform genera. Overall, tooth size decreased significantly as temperatures warmed during the Cenomanian, and particularly during OAE 2, in the whole assemblage. However, assemblage-scale changes may simply be due to differences in the composition of the fauna. One genus (*Scapanorhynchus*) was sufficiently abundant for individual analysis. Our results show that *Scapanorhynchus* teeth became smaller as temperatures rose during the Cenomanian, with a significant reduction in tooth size during OAE 2. Our results are consistent with the hypothesis that environmental changes, such as reduced oxygen concentration in seawater, caused a substantial decrease in the body size of lamniform sharks during OAE 2.

**GRANT INFORMATION:**

Commonwealth Scholarship Commission, United Kingdom and Department of Ocean and Earth Sciences, University of Southampton, United Kingdom.
Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)

REVISION OF DUGALDIA EMMITA (TELEOSTEI: ICHTHYODECTIFORMES) FROM THE EARLY CRETACEOUS OF AUSTRALIA.

BERRELL, Rodney W., Curtin University, Bentley, Australia; CAVIN, Lionel, Natural History Museum (MHNG), Geneva, Switzerland

The Australian record of Ichthyodectiform fishes is restricted to the Early – ‘mid’ Cretaceous, marine – brackish deposits of the Eromanga Basin of Queensland, Australia. In the original description the specimen (the only one in existence at the time) was attributed to the Neoteleostei because of the presence of a tripartite occipital condyle and placed in a basal position among neoteleosts because of the presence of several plesiomorphic characters. Two new specimens were recently recovered from the Early Cretaceous Toolebuc Formation of Dugaldia emmita is, in fact, an ichthyodectiform fish. The combination of features such as well-osseified ethmoid massif with a possible ethmopalatine ossification, a disc-like articular had of the autoplatine, a saber-shaped maxilla with two deep supramaxillae, large infraorbitals with elongated diverticulas of the infraorbital sensory canal, a participation of the exoccipital in the occipital condyle, the coronoid probably in contact with its counterpart, wide and elongated ribs with a groove along their length and articulating with their corresponding condyle via a complex parapophysis, elongated and deep supramaxillae and deepened long ovoid scales support the placement of this fish within Ichthyodectiformes and not as a basal neoteleost as suggested in the original study. The ichthyodectiforms present several specialised features of the jaw apparatus and Dugaldia possesses several of them (freely movable head of the palate, strong autosphenotic spine, loose symphyseis.) This fish, however, also possess very derived characters (articular process of the maxilla which is well-developed and allows the maxilla to switch laterally in an almost horizontal position, lateral face of the mandible with a large triangular fossa for the infralabial ligament and a row of teeth oriented horizontally along the oral margin of the mandible) indicating a very special jaw mechanics. It is likely that the fish was able to greatly enlarge its gape by lateral motion of the jaws. This characteristic was probably related to its mode of feeding – a possible ram-feeder on plankton – or for social interactions as in the Sarcantic Fringhead (Neolamia lepacia). This indicates Australia had a high diversity of Ichthyodectiform fishes comparable to the Western Interior Seaway of North America.

Technical Session XVIII (Saturday, October 12, 2019, 3:45 PM)

FIRST VIRTUAL ENDOCASTS OF TWO PALEOCEAN ARCTOCYONIDS: A GLIMPSE INTO THE BEHAVIOR OF EARLY PlACENTAL MAMMALS AFTER THE END-CRETACEOUS EXTINCTION

BERTRAND, Ornella C., University of Edinburgh, Edinburgh, United Kingdom; BEVERIDGE, Tegan L., James Cook University, Townsville, Australia; EVOLUTION IN NORTH AMERICA

We focus on the ‘Arctocyonidae’, a likely polyphyletic group of ‘condylarths’, including species potentially implicated in the origins of some extant orders. ‘Arctocyonidae’ were among the first placental groups to diversify after the end-Cretaceous extinction. They have been reconstructed as small- to medium-sized, mainly omnivorous and terrestrial. We obtained cranial and bone labyrinth endocasts for Chriacus baldwini and C. pelvidens from the lower Paleocene of the San Juan Basin, New Mexico, and Arctocyon primaeus from the upper Paleocene of the Paris Basin, France, via high-resolution computed tomography. Both share plesiomorphic brain features with previously described early Paleocene mammals. They have small lissencephalic brains with an EQ range of 0.12-0.43 and 0.16-0.31, respectively. The olfactory bulbs and the parafolliculi represent 6% and less than 1% of the total endocranial volume, respectively and the neocortical brain ratio represents ~25% of the total endocranial height. Based on the cochlear measurements, both taxa had hearing capabilities similar to those of extant wild bears. Agility scores between 2 and 3 were obtained for both taxa, similarly to the modern American badger and crab-eating raccoon, suggesting that C. pelvidens and A. primaeus had relatively similar mobility.

These results support growing evidence that early placentalts had lower EQs and less expanded neocortices compared to Eocene and later taxa, potentially indicating that high intelligence was not key to the placental radiation after the End-Cretaceous extinction.

Grant Information:
Marie Skłodowska-Curie Actions: Individual Fellowship, European Research Council Starting Grant, National Science Foundation, and Belgian Science Policy.

Technical Session II (Wednesday, October 9, 2019, 8:00 AM)

NEW HIGH-PRECISION U-PB GEOCHRONOLOGY FOR THE WAHWEAP FORMATION, SOUTHERN UTAH AND IMPLICATIONS FOR LATE CRETACEOUS DINOSAUR EVOLUTION IN NORTH AMERICA

BEVERIDGE, Tegan L., James Cook University, Townsville, Australia; ROBERTS, Eric M., James Cook University, Townsville, Australia; RAMEZANI, Jahan, Massachusetts Institute of Technology, Cambridge, MA, United States of America; TITUS, Alan L., Bureau of Land Management, Kanab, UT, United States of America

High precision temporal calibration of terrestrial vertebrate faunas by the U-Pb geochronology method has advanced significantly in the last decade. Bentonite marker horizons can be dated at 95% confidence level precision that now approaches 0.02%. This improved temporal constraint has significant implications for Late Cretaceous fossil localities that represent the height of dinosaur diversity in North America. The Kaiparowits Plateau in southern Utah has yielded plentiful new vertebrate taxa in the last two decades with a high concentration of discoveries coming from the Wahweap Formation in the Grand Staircase – Escalante National Monument. Important discoveries include early members of Tyrannosaurus and Ceratosaurus in this study, we systematically contextualised key taxa from the Wahweap Formation using high-precision geochronology and improved intraformational correlations.

Here we present the first high precision U-Pb ages for the Campanian Wahweap Formation using thermal ionisation mass spectrometry (CA ID TIMS) method. The findings of this study provide the basis for a revised temporal framework of the Wahweap Formation and taxa within. The Star Seep Bentonite (one of two Wahweap Fm. bentonites with published Ar-Ar geochronology [CF05-B]) was used as a distinctive horizon traceable across the formation. A northern and southern sample of the Star Seep Bentonite (B2-07B and WLS-R respectively) were collected and volcanic zircons from each were analysed using the CA ID TIMS approach. The two samples yielded statistically indistinguishable U-Pb dates thus confirming the correlation across 38 km and, most significantly, the results indicate a U-Pb date nearly 1.5 million years older than the previously published Ar-Ar date. This shift in the temporal framework has substantial implications for taxa from the Wahweap Formation. The type locality for the oldest known tyrannosaurid in North America, Lythronax argestes, is two metres below the southern Star Seep Bentonite sample locality. Another basal ancestor of significance is the oldest known ceratopsian Dibloceratops eatoni, identified from its type locality approx. 50 m stratigraphically higher than the newly dated bentonite. The new early Campanian age for the lower Wahweap Formation is considerably older than previously thought and has significant implications for understanding the timing and drivers of a major dinosaur diversification interval in the Santonian to early Campanian of the Western Interior Basin.

Grant Information:
This material is based upon work supported by the National Science Foundation under Grant No. 1424892.
The Triassic strata of the American Southwest, especially the Chinle Formation and Dockum Group, are critical to our understanding of Late Triassic faunal diversity and evolution. In recent decades, these strata have been informative regarding the evolution of close dinosaur relatives, which remain poorly sampled and enigmatic in their geographical distribution. Here, we describe and discuss a new non-dinosaurian dinosauromorph assemblage from the Los Esteros Member of the Santa Rosa Formation at the base of the Dockum Group in east-central New Mexico. This assemblage includes hindlimb fragments assignable to Silesauridae and Lagerpetidae. Much of the Formation and Dockum Group, are critical to our understanding of Late Triassic faunal diversity and evolution. In recent decades, these strata have been informative regarding the evolution of close dinosaur relatives, which remain poorly sampled and enigmatic in their geographical distribution. Here, we describe and discuss a new non-dinosaurian dinosauromorph assemblage from the Los Esteros Member of the Santa Rosa Formation at the base of the Dockum Group in east-central New Mexico. This assemblage includes hindlimb fragments assignable to Silesauridae and Lagerpetidae. Much of the Lagerpetid material is assignable to Dromomeron and has unusually large size. Based on a dataset of complete lagerpetid femora, we estimate a femoral length of 221.9 mm for one partial femur, making it the largest reported individual. In addition to the dinosauromorph specimens, we present biochronologic support that at least a portion of the Los Esteros Member corresponds to the Otschakian LV1 through the identification of non-Mystriosuchinae phytosaurs. Resultantly, we question the presence of a bifurcated lateral ridge on the squamosal of all phytosaurs currently assigned to Pararassuchus. This is the first Otschakian fauna identified from New Mexico, and it reveals lagerpetids achieved large body size earlier than previously known. Our identifications expand the geographical and temporal range of non-dinosaurian dinosauromorphs in the American Southwest. The material presented here, as well as an increasing number of Dromomeron specimens, demonstrate that non-dinosauriform dinosauromorphs could match or exceed the body size of many coeval dinosaurs.

Technical Session XVIII (Saturday, October 12, 2019, 2:00 PM)

The Early Cretaceous European Ambolestes and Its Implications for the Eutherian-Metatherian Dichotomy

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Extant placental and marsupial mammals are the dominant vertebrates in many ecosystems, which makes the placental-marsupial dichotomy a significant event in Earth’s history. Molecular estimates of the divergence of placental and marsupials (and their broader clades Eutheria and Metatheria) fall primarily in the Jurassic. In support, the oldest purported eutherian, Juramaia, is reported to be from the early Late Jurassic (160 million-years ago) of Liaoning Province, northeastern China. The oldest purported metatherian, Sinodelphys, is 35 million-years younger. From the Early Cretaceous Jehol Biota also in Liaoning Province, northeastern China. In 2018, we reported a new eutherian, Ambolestes zhoui, also from the Jehol Biota. The newly complete skeleton, preserves anatomical detail unknown from contemporaneous eutherians including the hyoid apparatus and ectotympanic. The complete hyoid is the first known for any Mesozoic mammaliform, and the ectotympanic resembles that in some extant didelphid marsupials. In our phylogenetic analysis concentrating on the eutherian-metatherian dichotomy, the closest relative of Ambolestes was Sinodelphys, and both fell within Eutheria. With Sinodelphys as a eutherian, postcranial differences formally thought to indicate different invasions of a sprawling niche by metatherians and eutherians are the same. In particular, the earliest known metatherians are approximately 15 million years younger than previously thought and their fossils, isolated teeth and fragmentary jaws, are from North America. Our new result in a 50-million-year-old lineage for Metatheria, accepting the 160 million-years age for Juramaia. A possibility raised elsewhere is that the age of Juramaia is incorrect; rather than Late Jurassic, perhaps it is from the Early Cretaceous Jehol Biota. In our study, Juramaia is in a clade with Albian/Aptian Probolomiammys and Late Cretaceous eutherians by having a more molariform ultimate upper premolar. In contrast, Ambolestes, as in the outgroups, has a non-molariform ultimate upper premolar. Although resolution of this intriguing debate is not currently possible, our understanding of the issues has been furthered by the discovery of Ambolestes.

Grant Information:
National Science Foundation Grant DEB 1654949 and YNSTC-YNU Joint Focus 2018FY001(005)

Using Dynamic Optimization to Simulate Locomotion in Extant and Extinct Archosaurs

BISHOP, Peter J., Royal Veterinary College, Hatfield, United Kingdom; FALISSE, Antoine, KU Leuven, Leuven, Belgium; DE GROOTE, Friedl, KU Leuven, Leuven, Belgium; HUTCHINSON, John R., Royal Veterinary College, Hatfield, United Kingdom

Archosaurs have displayed a wide array of locomotor habits throughout their 250 million year evolutionary history, including quadrupedal and bipedal terrestrial species, semiaquatic and marine forms, and two instances of powered flight. Understanding their history of locomotor specialization and innovation may therefore provide important insight into the patterns and processes of archosaur evolution. Computational biomechanical models of the musculoskeletal system provide a unique avenue to understand, simulate and recreate locomotion in extant and extinct archosaur species. In particular, in silico predictive simulations can explore musculoskeletal function and organismal performance under a range of conditions, beyond those that are measurable in experimental settings, enabling investigation of ‘what if’ questions. Under the assumption that a given behaviour maximizes some performance objective, dynamic optimization can be used to generate simulations of behaviours de novo, including maximal performance behaviours. Here, we explore the ability of direct collocation approaches to generating various maximum performance simulations in the fastest extant terrestrial archosaur, the ostrich. Direct collocation approximates the system dynamics over a series of short time intervals, obviating the need for explicit numerical integration, and the states (e.g., limb kinematics) and controls (e.g., muscle activations) throughout the entire behaviour are optimized simultaneously. By avoiding forward integration, the optimization problem can be solved very quickly using standard computing hardware. We have conducted simulations for running, walking and vertical jumping with an 18 degree-of-freedom, 68 muscle model, and these can generally be solved in under an hour. Our running simulation reaches a maximum speed of 15 m/s, comparable to that reported for wild ostriches. However, we have found that simulation performance and results are highly sensitive to how well ‘tuned’ the musculotendon parameters are, suggesting that certain simplifications may be necessary, particularly for modelling extinct species, such as using an ideal muscle model (i.e., independent of length or velocity effects) over the more traditional Hill-type model. Framed with circumstance caution and suitable sensitivity analysis, direct collocation dynamic optimization has great promise in enabling simulation of locomotor behaviours in extinct archosaurs.

Grant Information:
Supported by an ERC Horizon 2020 Advanced Investigator Grant (695517, to JRH)

Education and Outreach Poster Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)

Engaging and Exciting Pre-University Students in STEM via 3D Modelling of Dinosaur Anatomy and Biomechanics

BISHOP, Peter J., Royal Veterinary College, Hatfield, United Kingdom; CUFF, Andrew, Royal Veterinary College, Hatfield, United Kingdom; MICHEI, Krijn, Royal Veterinary College, Hatfield, United Kingdom; KERMODE, Louise, Royal Veterinary College, Hatfield, United Kingdom; HUTCHINSON, John R., Royal Veterinary College, Hatfield, United Kingdom

Dinosaur paleontology is well-known for its capability to engage students of all ages, and provides a strong basis for increasing understanding and interest in STEM (Science, Technology, Engineering, and Mathematics) topics. Likewise, three-dimensional digital and physical modelling appeals to students for its visually intuitive and technological aspects, and it can convey a wide variety of concepts of varying degrees of complexity. Combining these approaches can help maximize the scope and impact of STEM outreach work. Here we present a multi-faceted, multi-disciplinary approach that we have approaches can help maximize the scope and impact of STEM outreach work. Here we present a multi-faceted, multi-disciplinary approach that we have...
(1) Triassic–Jurassic paleontology, ecosystems, macroevolution and extinction; (2) osteology and limb proportions; (3) joint morphology, muscular anatomy and mechanical advantage; (4) body dimensions and computer models of centre of mass and (5) dynamic computer simulations of locomotor balance. Here we explain our approach, the rationale behind each topic covered, and the lessons we have learned from testing it with students. In particular, we have found that framing lessons in the context of group-based games can help inspire interest in concepts and topics that some students may otherwise find abstract or uninteresting, such as Earth history and Newtonian mechanics. Our approach introduces students to major concepts in biomechanics, behaviour, ecosystems and evolution, as well as how it can be fascinating in its own right.

Grant Information:
Supported by an ERC Horizon 2020 Advanced Investigator Grant (695517, to JRH)

Technical Session XI (Friday, October 11, 2019, 11:00 AM)

NETWORK ANALYSIS UNVEILS THE FUNCTIONAL SUCCESSION OF IBERIAN MAMMALIAN FAUNAS OVER THE LAST 20MY

BLANCO, Fernando, Museum für Naturkunde, Berlin, Germany; MARTÍN-PEREÁ, David M., National Museum of Natural Sciences - CSIC, Madrid, Spain; DOMINGO, Maria Soledad, Universidad Complutense de Madrid, Madrid, Spain; CALATAYUD, Joaquin, Umeå University, Umeå, Sweden; MENÉNDEZ, Iris, Universidad Complutense de Madrid, Madrid, Spain; HERNÁNDEZ FERNÁNDEZ, Manuel, Universidad Complutense de Madrid, Madrid, Spain; CANTALAPIEDRA, Juan L., Universidad de Alcalá de Henares, Alcalá de Henares, Madrid, Spain

One potential conservation strategy in the context of current environmental crisis is to preserve functional diversity with the hope that ecosystems and species pools will increase their chances against future environmental disturbances. To complement neontological perspectives, an interesting approach is to track functional faunas over deep timescale and to evaluate the resilience of functional-diverse systems during past events of ecological disturbance. To do so, we investigated functional morphology trends of Iberian peninsula macromammals during the last 20 my. Our dataset includes functional information for 386 species grouped in 102 functional entities (i.e., unique combinations of functional traits). We use network analysis framework to assess the functional evolution of these faunas. Besides, we estimate changes in functional disparity, functional redundancy and functional vulnerability, and compare these trends with speciation and extinction dynamics over the analyses interval. Using network analysis community detection algorithms we identified 11 “functional communities”, defined as groups of localities that harbor similar functional entities (FE) over time. We observe the substitution of these communities during the studied time interval in relation to changes in functional diversity. Functional redundancy peaks were followed by accelerating extinction and a marked species lost, typically extirpating species with the same functional ecology. The resulting system show low functional redundancy and eventually would rebound its resilience by gaining species with existing ecological roles. In terms of FE, the recovery after episodes of functional depletion were followed by a stasis or slow recovery. In particular, we observe periods of sustained positive and moderate diversification rates, fueled by a progressive increase in FE and broadening of the multivariate functional space (a pattern observed between 14-9, and 6-1Ma). Coinciding with these patterns we observed the replacement of highly diverse functional communities by less diverse ones. After the extinction event around 9 Ma, the system underwent an increase in functional disparity and richness at the expense of increasing its functional vulnerability (many ecological roles played by just one species), which enhanced the biotic collapse of the Iberian faunas during the Messinian Salinity Crisis. We show that the use of network analysis in paleobiology is not limited to taxonomic entities, but can also be successfully applied to functional units.

Grant Information:
This project was funded by the Deutsche Forschungsgemeinschaft, the Talent Attraction Program of the Madrid Government, and the Marie Skłodowska-Curie Program.

Technical Session XX (Saturday, October 12, 2019, 2:00 PM)

BIOMECHANICAL RELEASE: LOADING REDUCTION AS A PATHWAY FOR MORPHOFUNCTIONAL CHANGE IN THE SKELETONS OF VERTEBRATES ACROSS EVOLUTIONARY TRANSITIONS IN HABITAT

BLOB, Richard W., Clemson University, Clemson, SC, United States of America; YOUNG, Vanessa K., St. Mary's College, Notre Dame, IN, United States of America; MUNETANU, V. D., Clemson University, Clemson, SC, United States of America; MAYERL, Christopher J., NEOED, Rostostown, OH, United States of America; DIAMOND, Kelly M., Clemson University, Clemson, SC, United States of America; KAWANO, Sandy M., CSU Long Beach, Long Beach, CA, United States of America

The relationship between structure and function is a central paradigm for understanding the diversity of biological form. For the skeletons of vertebrates, one of the main required functions is bearing the loads imposed by the actions of muscles and support of body weight. Differences in such loads across species are often viewed as a factor that contributes to differences in the shapes of their skeletal elements. One of the main sources of variation in loading across taxa is differences in the physical conditions imposed by how organisms move through different habitats. During evolutionary habitat transitions, changes in loading conditions might impose selection that could favor corresponding changes in skeletal morphology. For example, the limb bones of modern sprawling tetrapods are exposed to high torsional loads during walking on land. In this context, evolutionary changes in limb bone shape during the invasion of land by tetrapods, from a bipedal to a tetrapedal morphology, could be viewed as changes that improve resistance to torsion. However, as a counterpoint to transitions in which increases in particular loading regimes favor specific changes in skeletal morphology, the invasion of habitats in which loads diverge might allow a “biomechanical release” from demands, providing an opportunity for skeletal structure to diversify. We tested this possibility by recording limb bone strains from swimming and walking turtles and using X-ray Reconstruction of Moving Morphology (XROMM) to evaluate long axis rotation of the proximal limb bones. These recordings showed much lower torsion during swimming than during terrestrial walking. Thus, release from the biomechanical demand of resisting torsion may have led to conditions that enabled the evolution of limb bone shapes other than tubes suited to resist torsion, such as the flat limbs found in flapping lineages like sea turtles. However, some shape changes in new habitats might evolve despite disadvantageous changes in loading. For example, the limbs of arboreal taxa are often longer than those of terrestrial relatives, and longer bones typically have a greater risk of failure during running over level ground. Our data show this risk is not reduced by loading changes in arboreal habitats: strain data from the femur of green iguanas show higher, not lower, loads during climbing behaviors. Thus, although loading may have mediated the evolution of bone shape during some transitions, tradeoffs with functional demands other than loading may also have shaped bone design in other environments.

Technical Session IX (Thursday, October 10, 2019, 3:45 PM)

NEW TERRESTRIAL VERTEBRATES FROM THE PALEOGENE OF INDONESIA

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Wallace’s Line today demarcates the separation between an Asian biotic province in northern Oceanic Southeast Asia (OSEA) and an Australian biotic province in southern OSEA, thought to have resulted from northward movement of the Indo-Australian plate towards and along the Sunda Shelf. Terrestrial Paleogene vertebrates from OSEA have been largely unknown, limiting our ability to understand the timing of the development of this biogeographic pattern. Recent fieldwork (2012-2014) in West Sumatra has resulted in recovery of a diverse array of terrestrial Paleogene vertebrates contemporary with the initial emergence of the Sunda Shelf Islands. Fossils come from the Ombilin Basin, Functional Hinge at Tanahabang Village Road Cut locality. The fossil bearing layer is in the lower part of the late Eocene/early Oligocene Sawahlunto Formation characterized by thin coal
seams in a rooted siltstone, mudstone and limestone succession interpreted as deposits in a terrestrial setting. Fossil turtles are the first known from the Paleogene of Indonesia and include: Geomomydidae (old world pond turtles); Testudinidae (land tortoises); and Trionychidae (soft-shelled turtles), the latter with a finely pitted and posteriorly multi-keeled carapace similar to forms found in Asia today. Crocodyliform fossils include a partial braincase, postcrania, osteoderms, and posteriorly multi-keeled carapace similar to forms found in Asia today. Trionychidae (soft-shelled turtles), the latter with a finely pitted and posteriorly multi-keeled carapace similar to forms found in Asia today. Trionychidae (soft-shelled turtles), the latter with a finely pitted and posteriorly multi-keeled carapace similar to forms found in Asia today. The first definitive mammal, a single rodent incisor, was recovered in 2014. The enamel microstructure has a unique combination of characteristics that suggest possible affinities to a ctenodactyloid-hystricognath clade. We also found a podocenemid pleurodire (side-necked turtle), the first record from OSEA, from the middle to late Eocene Tectone Tanjung Formation in southwestern Kalimantan indicating that further exploration in the Paleogene of Indonesia is likely to be successful. Discovery of a Paleogene terrestrial vertebrate fauna with Asian affinities is consistent with tectonic reconstructions that suggest a later Oligocene contact between the Sunda Shelf and Australia.

Grant Information:
National Geographic Society Grants W223-12 & 227-13 (to GFG, RLC), Grant from the Gordon Getty Foundation (to GFG, RLC)

Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)
A PATHOLOGIC TURTLE SHELL FROM THE PALEOGENE UPPER HORNERSTOWN FORMATION AT THE EDELMAN FOSSIL PARK, GLASSBORO, NEW JERSEY

BOLES, Zachary M., Rowan University, Glassboro, NJ, United States of America; HIERBACHER, Michael, Edelman Fossil Park of Rowan University, Glassboro, NJ, United States of America

Shell lesions and other pathologies are not uncommon in extant turtles, especially aquatic species. Pathologies have also been noted in several fossil turtles, although many in-depth studies and descriptions are lacking. Recently, an associated skeleton of the sea turtle, Catapleura repanda, was excavated from the Upper Hornerstown Formation at the Edelman Fossil Park in Glassboro, New Jersey. The specimen consists of at least six costals, six peripherals, plastron elements, pubes, ilia, a limb bone, and other bone fragments. Pathologic pitting, holes, and excess bone growth are present in several of the costals and are restricted to the medial one-third of the elements. Some lesions present as smooth-walled depressions on the dorsal surface of the costals. The nearly circular pits range in size from 12 to 20 mm in diameter and approximately 9 mm deep. On the ventral surfaces of these bones, there is a complimentary ‘bulge’ directly beneath the pits. In other instances, the bone has been completely resorbed, resulting in a hole in the bone. The edges of these holes are smooth and intact indicating that they are not taphonomic artifacts. A slightly raised rim is present around portions of the holes on the dorsal surface. On another costal, there is a cluster of two large ovoid pits and a small circular pit. The smaller lesion is ~5 mm in diameter whereas the larger ovoid lesions are between 14 and 20 mm in maximum diameter. On the ventral surface of this costal, there is excess bone growth, giving the bone a roughened or filigree texture. The etiology of turtle shell lesions is highly debated, and a confident identification may only be possible in living turtles in clinical settings.

Consequently, this specimen is identified as having shell disease, a broad term that describes various types of damage to the shell of turtles. Possible causes include bacterial, algal, or fungal infections or healed bite-marks from failed predation attempts. The location and distribution of the lesions seems to rule out bite-marks or scars from rocky substrates. The filigree texture seen on the ventral surface of the one costal is consistent with osteomyelitis and suggests that the lesions are the result of some type of infection.

Technical Session IX (Thursday, October 10, 2019, 2:15 PM)
NEW INSIGHTS ON LEPIDOSAUR EVOLUTION AS INFORMED FROM EVOLUTIONARY RATES AND DISPARITY ANALYSIS

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Lepidosaurs (squamates and rhynchocephalians) form one of the most speciose clades of tetrapods. Despite their success in terms of both taxonomic and morphological diversity, the early evolutionary history of lepidosaurs and their diversity of morphological expressions are poorly understood. New insights on the evolutionary history of lepidosaurs from a macroevolutionary perspective. For this, we performed multiple evolutionary rates and disparity analyses using morphological data matrices as the source of information. Despite a very poor Middle and Late Jurassic fossil record for squamates (which is even more underrepresented in morphological matrices, where complete and informative specimens are favored), our results suggest there was a notable evolutionary radiation during this time. Disparity analyses show that there was a great expansion of morphospace among lepidosaurs in the Middle-Late Jurassic, coinciding with the confluence of all major morphotypes. This morphospace does not undergo great modifications in subsequent times, only slightly expanding and becoming more densely populated. Some metrics of relative disparity through time point to the Middle-Late Jurassic as the interval of maximal disparity, or, alternatively, show this time as an inflection point initiating steadily rising disparity towards the present. Evolutionary rate analyses record a first spike of high rates in the Late Jurassic, and a second in the Late Cretaceous. Despite the appearance of several new clades in the Late Cretaceous, we regard this second spike as more problematic, as denser sampling can result in inflated rates because of the associated shortening of branches. In summary, a sudden increase in morphospace, a spike representing high rates of morphological evolution, and the presence of the earliest fossil occurrences of many crown groups, all point to a great adaptive radiation occurring no later than the Middle-Late Jurassic. Signals for a great evolutionary radiation persist when rhynchocephalians are removed, suggesting that it is highly related to the evolution of squamates. A Jurassic squamate radiation had been suggested only on the basis of the crude analysis of the composition of the fossil record, but we provide further support for this interpretation from analyses that need fewer a priori assumptions. Despite the recovered high rates in our results do not support an adaptive radiation of squamates linked to the Cretaceous Terrestrial Revolution.

Grant Information:
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Regular Poster Session III (Friday, October 11, 2019, 4:15 - 6:15 PM)
NEW EMBRYOLOGICAL AND PALEONTOLOGICAL EVIDENCE SUPPORTS LIGHT ON THE EVOLUTION OF THE ARCHAOSUROMORPH ANKLE

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The homology and evolution of the archosaur ankle is a controversial topic that has been deeply studied using both fossil and extant evidences. In stem-archosaurs, the astragalus and calcaneum form the ancestral proximal tarsus and a single ossification composes the centrale series. In more recent stem-archosaurs, the centrale has been incorporated into the archosaur astragalus and contradict the presence of a tibiale in bird embryos. The latter bolsters previous embryological studies that have concluded that the tibiale never develops in amniotes.

Grant Information:
Préstamo BID-PICT 2019-0159 (PB)

Technical Session IX (Thursday, October 10, 2019, 3:15 PM)
EXPLORING ELBOW KINEMATICS OF THE CENTRAL BEARDED DRAGON (POGONA VITTICEPS) USING XROMM: IMPLICATIONS FOR ANCESTRAL AMNIOITE ELBOW FUNCTIONAL MORPHOLOGY

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Lizards are a successful group of squamate reptiles that retain the non-erect limb posture of the ancestral amniote. Thus, understanding lizard locomotion has far-reaching implications for inferring ancestral limb posture and range of movement in both reptiles and mammals. Despite decades of research on lizard locomotion, the mechanics of the elbow joint and its relationship to manus orientation remain understudied. Previous studies on monitor lizards have inferred from dissection and X-ray cine that manus pronation is dictated by long-axis rotation of both the radius and ulna relative to the humerus. To further explore the kinematics of the lizard elbow, we used XROMM (X-ray Reconstruction of Moving Morphology) to explore elbow movements in the central bearded dragon, *Pogona vitticeps*, a docile and hardly lizard native to Australia. Lizards were trained to walk on a trackway, and videofluoroscopes captured their movements from two calibrated perspectives. Taut halluc markers were affixed to the forelimb and body axis with medical tape to improve accuracy and semi-automate the reconstructions. Our results show that during stance (the portion of the step cycle when the manus is in contact with the ground), the forelimb is retracted and pronated laterally on their long-axes relative to the humerus, especially during elbow flexion. Given that the radial and ulnar condyles of the humerus have different morphologies, the antebrachial bones follow different paths at the elbow, resulting in their distal ends moving in opposite directions. Collectively, these movements of the radius and ulna maintain palmar contact of the manus with the ground during stance in what can be described as the squamate equivalent of pronation. At the end of stance and the beginning of swing (the portion of the step cycle where the manus is lifted off the ground and the forelimb is protracted), the long-axis rotations of the radius and ulna reverse, rotating medially relative to the humerus, allowing the manus to supinate. Our data are in agreement with previous work on the elbows of monitor lizards which showed a similar pattern of antebrachial movements. We find it significant that manus pronation is maintained in part through movements of the radius and ulna (lateral long axis rotation) typically associated with supination in birds and (at least for the radius) in mammals. Our data suggest that we need more models and examples of elbow kinematics across reptiles and mammals to enhance our understanding of the ancestral mechanism for amniote pronation and supination.

Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM)

**LIFE HISTORY PATTERNS IN EARLY JURASSIC DINOSAURS FROM SOUTH AFRICA**

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**CHAPPELL, Kimberley, University of the Witwatersrand, Johannesburg South Africa;**

**WEISS, Bailey, University of the Free State, Bloemfontein,**

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The end-Triassic mass extinction (ETE) was one of the five most catastrophic mass extinction events in Earth’s history, witnessing the loss of non-crocodylomorph pseudosuchians, phytosaurs, and most non-mammalian theropods. The radiation of Late Triassic and Early Jurassic dinosaurs suggests that they were not negatively affected by the extinction event, but the difficulty in finding body fossils in a complete or near-complete sequence containing the ETE has hampered our understanding of ecosystem reorganization that began at this time. The Elliot Formation in South Africa has an excellent continental record of uppermost Triassic and lowermost Jurassic strata with abundant dinosaur fossils, providing an opportunity to examine the life histories of dinosaur taxa that lived during the earliest Jurassic post-extinction environment. Osteohistology in vertebrates can be used to assess life histories because it is known to reflect growth rates and patterns, ontogenetic stages, reproductive maturity, biomechanical adaptations, lifestyles and potentially the effects of significant environmental perturbation on growth. High mortality rates affect populations in unstable, resource-limited environments such as those that form during mass extinction events, and species exhibiting different life history strategies might be expected to respond differently to critical biotic or abiotic factors. We examined the osteohistology of several dinosauromorphs from the Elliot Formation including *omithischians, theropods* and the abundant sauropodomorph *Massospondylus* to assess their life history patterns. All taxa reveal rapidly forming, highly vascularized fibrolamellar bone tissues intermittently interrupted by temporary decreases (annuli) or cessations (Lines of Arrested Growth) in growth. However, *Massospondylus* and the *omithischian Lesothosaurus* reveal a degree of developmental plasticity in the form of irregularly spaced growth marks showing inconsistent periods of rapid growth throughout ontogeny. Ontogenetic plasticity may have been a key feature in allowing these dinosaurs to have had a high rate of survival during the post-extinction earliest Jurassic environment following the ETE.

Grant Information:

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Regular Poster Session III (Friday, October 11, 2019, 4:15 - 6:15 PM)

**NASAL PASSAGE GROWTH THROUGH ONTOGENY IN THE LAMBDEOSAURINE PARASAUROLOPHUS (ORNITHOPODA: DINOSAURIA)**

**BOURKE, Jason, New York Institute of Technology College of Osteopathic Medicine at A-State, Jonesboro, AR, United States of America; GATES, Terry A., North Carolina State University, Raleigh, NC, United States of America; ZANNO, Lindsay, North Carolina Museum of Natural Sciences, Raleigh, NC, United States of America**

The cranial crest of *Parasaurolophus* is a signature feature of the genus. As with all lambeosaurines, this crest housed remarkably elongate nasal passages at least twice the length of the crest itself. Published CT scans of the ontogenetically youngest known *Parasaurolophus* skull (RAM 14000; Raymond M. Alf Museum of Paleontology at the Webb Schools, Claremont, California, U.S.A.) from the Late Cretaceous Kaiparowits Formation (Grand Staircase-Escalante National Monument, Utah) indicated that the crest originated in juveniles as a continuation of the nasolacrimal duct. In adults, this duct undergoes an extreme lateral diverticulum now a continuation of the dorsal and ventral ascending tracts. An extra nasal loop deep within the cranial of the composite adult specimen was retained in the morphed juvenile airway. Poor preservation in this region of the RAM 14000 cranium makes it difficult to determine if this loop was osteologically bouldered or if this was an artifact of the morphing process. Resonance calculations of this longer, juvenile nasal passage resulted in slightly lower harmonic frequencies than originally estimated for RAM 14000, albeit still higher than the harmonic frequencies calculated for the adults. Our revised interpretation suggests that the basic shape of the nasal passage in *Parasaurolophus* was in place prior to hatching, and that regional nasal passage length change occurred through ontogeny.

Technical Session XVIII (Saturday, October 12, 2019, 2:30 PM)

**EXPLORING LATE CRETACEOUS PATTERNS OF TAXONOMIC AND ECOLOGICAL DIVERSIFICATION AMONG NORTH AMERICAN STEM MARSUPIALS (PEDIOMYIDS AND ALPHADONTIDS)**

**BRANNICK, Alexandria L., University of Washington, Seattle, WA, United States of America; FULGHUM, Henry Z., University of Washington, Seattle, WA, United States of America; SMITH, Stephen M., Field Museum, Chicago, IL, United States of America; WILSON, Gregory P., University of Washington, Seattle, WA, United States of America**

Metatherians (the clade that includes marsupials and their closest therian relatives) exceeded eutherians (the clade that includes placentals and their closest therian relatives) in taxonomic richness prior to the Cretaceous-Paleogene mass extinction. In North America, metatherians underwent a Cretaceous taxonomic radiation, in which five major lineages diverged by the Albian-Cenomanian-late Santonian (100–85 Ma). However, in contrast to their taxonomic diversity, North American Cretaceous metatherians have been conventionally viewed as having little dietary diversity and have been seen as mostly insectivorous. To assess the amount of ecological expansion metatherians underwent during the Cretaceous, as well as how patterns of dietary diversification relate to patterns of taxonomic richness through time, we analyzed metatherian dental morphology and function within a temporal and phylogenetic framework.

We generated 3D digital elevation models (DEMs) from microCT data of extant and fossil metatherian molars to characterize dietary ecology. We generated 3D digital elevation models (DEMs) from microCT data of extant and fossil metatherian molars to characterize dietary ecology. We focused this pilot study on only pediomyid and alphadontid metatherians; we sampled upper third molar specimens of eight pediomyid species and 12 alphadontid species from the Morrison Formation in Wyoming. The extant sample consists of 25 mammalian species that span a variety of dietary ecologies. Extant sampling included both marsupial and placental taxa, as the methods...
used to assess dietary ecology are assumed to be homology-free. From the 3D DEMs of the sampled fossil specimens, we quantified morphological disparity and inferred diet from dental topographical measures (DIT), including relief index, Dirichlet normal energy, and orientation patch count—all of which have been shown to correlate with diet in extant mammalian taxa. Preliminary results show that pedomyids have higher values of disparity—calculated as the variance of each DTM—than present in alaphodonts. This dietary expansion of pedomyids may be related to the broadly concurrent ecological radiation of angiosperms. Increased ecological richness of angiosperms may have provided new dietary niches for these metatherians to exploit. Because dietary expansion appears to coincide with taxonomic diversification, our results may imply that dietary ecology expansion may be a driving factor behind the taxonomic diversification seen in at least pedomyids.

Grant Information:
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Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM)

INSIGHTS INTO DINOSAUR TRACKING IN THE 21ST CENTURY USING PHOTOGRAMMETRIC ICHNOLOGY AND NEONICHNOLOGY OF EMUS

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Over the course of the past 20 years, Middle Jurassic (Bathonian) dinosaur tracks have been intensively documented in the northern Bighorn Basin of Wyoming. Evolving state-of-the-art geospatial techniques were used to capture 3D data for scientific, interpretive, and management purposes. Close-range photogrammetry was used for the proper documentation, preservation, and assessment of ichnological resources in this region, as stereo images have the quality, reliability, and authenticity necessary for scientific use. To better understand the taphonomic, ontogenetic, and behavioral implications of these fossil footprint data, neochiologicstudies were undertaken.

In particular, field observations of modern emus (Dromaius novaehollandiae) making tracks and trackways, provided direct comparison of the actions and activities of trackmakers with the traces they leave. To that end, various ichnological data were collected from Australia’s national bird (i.e., emu) of various ages, so that track formation could be better understood and footprint growth curves developed. Footprint length scaled well with age, weight, and other variables. In addition, observations of modern ground birds provide insight into the complexities associated with gaits. Although most theropod trackways represent walking gaits, it is apparent that trackways may not always represent continuous movement, as some animals may stop midstride (e.g., “start-stop walking”), which is not preserved in ichnite morphology. Also, puzzling trackways, such as those with pace angulations greater than 180 degrees (e.g., crossovers) and seemingly random orientations in disturbed areas, relate to those of modern emus. These studies assist in the understanding of spacing, movement patterns, age distributions, and community dynamics, represented by footprints. The Middle Jurassic Sundance Formation Vertebrate ichnofaunal Province of the Bighorn Basin (where thousands of Carmelopus undertracks are arranged into hundreds of trackways) provides evidence for a monotypic population of terrestrial theropods traveling in various family groups. Here and other places around the world, neichnological photogrammetric ichnological studies are being used to help unravel numerous ichnological complexes and provide unique glimpse of the paleoecology, paleobiology, and paleoethology of dinosaur communities.

Symposium: Origin of a Sunburnt Country (Saturday, October 12, 2019, 8:15 AM)

DIETARY NICHE SEPARATION IN LATE MIOCENE TO RECENT HYPSELODONT WOMBATS

BREWER, Philippa, The Natural History Museum, London, United Kingdom

Hypsilodont (euthypsonodont) teeth have evolved multiple times in distantly related mammals. New dental material is continuously added to the base of hypsilodont teeth during life to compensate for high rates of wear at the occlusal surface. There is a positive correlation between the presence of hypsilodont cheek teeth and a grazing diet (i.e., monocotyledonous plants forming >90% of food intake) owing to the abrasive nature of ingested plant fibers and/or grass. Wombats (Vombatidae, Diprotodontia) are the only Australian marsupials to have evolved hypsilodont cheek teeth and all three extant species are grazers. Hypsilodonty evolved in wombats in the Tortonian (late Miocene) and from an earlier study using a broader taxonomic data set. Muzzle shape was only weakly correlated with diet. Molars of the late Miocene to Pleistocene pleistochromic wombat, Warendris, have a strong attritional signal; whereas molar wear in living wombats is strongly abrasive. Extension of the analysis to other Plio-Pleistocene wombat results in a series of hypotheses which can now be tested using additional techniques such as microwear. Potential correlation between occurrences of these taxa in the fossil record and climate change is discussed.

Symposium: From Molecules to Macroevolution (Wednesday, October 9, 2019, 8:00 AM)

TRENDS IN SOFT TISSUE PRESERVATION AND ITS ROLE IN REVEALING THE HISTORY OF LIFE

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The common perception of the vertebrate fossil record is bones, scales and teeth and, more rarely, eggshell. Associated biomolecules and their potential significance have received relatively little attention with the exception of ancient DNA and its celebrated applications. In this respect research on fossil vertebrates differs from that on invertebrates and plants where organic cuticles, for example, are a much more significant component of the fossil record. Analyses of fossil samples and experiments have shown how lipids in arthropod cuticles and leaves are transformed into longer chain hydrocarbons with a higher preservation potential. Conodont elements have long been used both in biostratigraphy and as an indicator of thermal maturity based on diagnostic color change in their organic components but without the realization that organics in familiar vertebrate hard tissues are similarly affected. The neglect of biomolecules in fossil vertebrates was a result, at least in part, of a poor understanding of taphonomy – what settings favor biomolecular preservation in vertebrate tissues and what processes are involved – and limited analytical approaches. Recent discoveries have transformed the potential utility of biomolecules in vertebrate fossils. The pigment melanin has been shown to be one of the most degradation resistant biomolecules, which can survive largely intact at least as far back as the Jurassic. Fossilized melanin has provided a method for reconstructing color in fossil vertebrates both within and outside melanosomes (the organelles preserved in fossil fur and feathers). Just as significant is the demonstration that vertebrate hard tissues in particular sedimentary settings sequester soft tissue remains. The composition of this material (protein, lipid, and polysaccharide fossilization products) retains a chemosystematic signal that is diagnostic of particular taxa and reflects affinities and metabolic rate. Such data can enhance paleoecological reconstructions, inform phylogenies, and assist in the placement of problematic taxa. Combined with new analytical approaches, ancient biomolecules in vertebrate hard tissues have the potential to provide increasingly powerful complementary evidence to fossil remains in revealing the history of vertebrate life.

Technical Session IV (Wednesday, October 9, 2019, 2:30 PM)

TOOTH REPLACEMENT RATES IN HETERODONT REPTILES

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Tooth replacement frequency in polyphyodont animals is tightly correlated with tooth function, diet, and dental evolution. The tooth replacement process involves perfect timing between initiation, development, eruption, and shedding. A common method used to calculate replacement rates in fossils is the examination of histological sections or high resolution microCT scans to count lines of von Ebner in the dentine of sequential teeth at one tooth position, which gives an estimate of the time between the initiation of each tooth. The rate calculated for that tooth position is often averaged to get an estimate of tooth replacement rates for the whole mouth. This is generally not a problem for animals with homodont dentitions, where teeth are the same size and shape around the mouth. However, this could be problematic for animals with heterodont dentitions, where teeth of different sizes may have different developmental times, and therefore estimates of tooth replacement rates based on one tooth position may not be an accurate representation of the whole mouth.

To test whether animals with heterodont dentitions have different tooth replacement rates based on position in the mouth, a dataset of X-rays collected at each position, which gives an estimate of the time between the initiation of each tooth. The rate calculated for that tooth position is often averaged to get an estimate of tooth replacement rates for the whole mouth. This is generally not a problem for animals with homodont dentitions, where teeth are the same size and shape around the mouth. However, this could be problematic for animals with heterodont dentitions, where teeth of different sizes may have different developmental times, and therefore estimates of tooth replacement rates based on one tooth position may not be an accurate representation of the whole mouth.

To test whether animals with heterodont dentitions have different tooth replacement rates based on position in the mouth, a dataset of X-rays collected at each position was examined. X-rays from Dracarena (n=2), Varanus (n=2), Teiss (n=2), and Alligator (n=2) were collected monthly or bimonthly for up to two years. For this study, the X-rays were examined for presence or absence of replacement teeth, and shedding events were scored over the data collection interval. Results show that larger teeth have longer development times than smaller teeth, however, eruption and shedding times are uniform between positions around the mouth. For example, in Dracarena and Alligator, a tooth at each position shed once a year, however, the large molarsiform and caniniform teeth take eight months to develop while the smaller conical teeth shed two months. These data suggest that, surprisingly, calculations of tooth replacement in heterodont animals based on one tooth position might in fact be accurate, it is actually the timing of tooth development that differs between tooth positions while shedding frequencies are consistent. These differences in tooth development times may be key to understanding how variation in tooth morphology arises over evolutionary timescales, such as the differences between premaxillary and maxillary teeth in homodont animals or more pronounced tooth modules, such as incisors, canines, and molars in mammals.

Grant Information:
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Technical Session XIII (Friday, October 11, 2019, 2:15 PM)

STILL STRANGER THINGS: MICRO CT IMAGING OF 3D DREPAANOID SKULLS AND SKELETONS (SAINTS & SINNERS QUARRY, LATE TRIASSIC, EOLIAN/INTERDUNAL NUGGET FORMATION) REVEALS BIZARRE AND NOVEL MORPHOLOGIES INCLUDING A BEAK COMBINED WITH TRANSVERSELY WIDE TEETH, SAUROPOD-LIKE PNEUMATIC DORSAL VERTEBRAE, A CHEVRON THAT ARTICULATES WITH THE PELVIS, AND TRIPODAL ADAPTATIONS

BRITT, Brooks B., Brigham Young University, Provo, UT, United States of America; PRITCHARD, Adam C., National Museum of Natural History, Washington, DC, United States of America; CHUÈRE, Daniel J., Retired, Johannesburg, SA, United States of America; ENGELMANN, George F., Utah State University, Logan, UT, United States of America; MCNULTY, Kieran P., University of Minnesota, Minneapolis, MN, United States of America

With a bird-like head, mole-like arms, and a "claw" at the end of the tail, derived deinodonts (lizard-sized neodiapsids) are highly enigmatic. Multiple 3D skeletons of a new deinodont taxon from Utah provides insights into this clade, previously known from flattened skeletons and isolated 3D elements.

The braincase of the skull is edentulous with elongate nares (>50% of rostrum). Teeth are transversely broad. Upper tooth rows are offset medially with the posteriormost upper teeth separated from the jugal by a broad suborbital fenestra. Mandibular rami are fused and rostrally edentulous. The dentary teeth extend nearly to the posterior end of the mandible, and the tooth row is rotated medially along its long axis. The jaw joint is ventral to the tooth row. The quadrate tapers dorsally, lacks a cephalic condyle articulation with the squamosal, and lacks a posterior concavity, indicating the absence of an external ear. The frontal and parietal are large and their endocranial contributions dorsoventrally inflated. Dorsal vertebrae are lightly built. The ventral portion of the anterior cotyle of the centrum is absent, perhaps facilitating hyperflexion. Dorsal vertebrae are convergent with saurapod vertebrae in having proportionally large, pneumatic ventral/lateral fossae on the centrum and elongate fossae and thin laminae on the neural arch. The apices of the neural spines of dorsals 2-3 are anteroventrally elongated, transversely thick, and fused into a "notarium" with a sulcus on each side of the elongated spine of 2 that receives the tip of the rod-like scapulae.

Contra other deinodonts, the ilium has large anterior and posterior blades and von Ebner in the dentine, extending ventrally to the level of the sacrum. Anteriorly, it is laterally wide and posteriorly bladiform terminating ventrally in a plate. When the tail is ventroflexed (and the tail "claw" in a substrate) this plate abuts the elongate ischia, firmly bracing the tail to the pelvis to form, along with the large feet, a tripod stabilizing the rigid tubular trunk during scratch digging with the arms. This tripod stance is further facilitated by large iclade blades that act as the origins of large muscles to bridge the body and tail.

The Utah taxon inhabited playa flats in an enormous dunefield. Such finds can indicate modern nearshore conditions or a closer relationship to the Nile crocodile (Crocodylus niloticus) currently living in the region. Here, we describe an assemblage of crocodylids from several early to middle Miocene sites in Kenya. The specimens are housed the Department of Earth Sciences, National Museums of Kenya. The most completely known of these is based on a skull and lower jaws from Maboko (Serravallian, Lake Victoria Basin). The snout is comparatively short and deep, broadly resembling those of the modern mugger (C. palustris) and Morelet's crocodile (C. moreletii). New species with somewhat longer snout are known from Karusino (Lake Victoria Basin) and Lopérot (Turkana Basin), both of putative Burdigalian age. The largest known specimens of each derive from 3.5 to 4 m long individuals. These forms lack features diagnostic of Crocodylus, such as a derived arrangement of the medial and lateral Eustachian openings and basisphenoid in posterior view. They do, however, share derived characters with the modern African dwarf crocodiles (Osteolaemus), such as a thin crest circumscibing the internal choana. Phylogenetic analysis supports a close relationship between these forms and a closer relationship to Osteolaemus (which rarely exceeds 2 m in length) than to Crocodylus.

This new clade of osteolaemines disappears shortly after the Middle Miocene Climatic Optimum and the early transition from continuous forest to grassland-savannah biomes in the region. Another osteoelammin, Brochuchus, disappears at approximately the same time. The only crocodyliforms found throughout the Miocene in the area are longirostine forms (gharials and Euthycodon). Modern Osteolaemus is restricted forested wetlands, suggesting the contraction of osteolaemine diversity in East Africa was driven by changes in vegetation. This is consistent with the presence of a possible close relative in the late Miocene of western Uganda, where forested conditions persisted. The appearance of Crocodylus in the late Miocene might reflect its more relaxed environmental preferences.

US National Science Foundation DEB 1257786-125748 Research on East African Catarrhine and Hominoid Evolution (REACHE)
ON THIN AIR: VENTILATION MECHANICS IN LIVING AND FOSSIL BIRDS

BROCKLEHURST, Robert J., University of Manchester, Manchester, United Kingdom

Modern birds have a highly modified ribcage associated with both a uniquely efficient respiratory system and powered flight. The avian fossil record preserves the sequence of transformations in ribcage anatomy related to the origins of flight, but how these changes affected respiration & ventilation mechanics remains unclear. Reconstructing the evolution of breathing requires integration of anatomical, kinematic and physiological data. Here, I combine these multiple data streams to create multi-body dynamics musculoskeletal models, and use evolutionary robotics optimization approaches to estimate muscle activation patterns, ventilatory movements and – for the first time in a simulation study – the energetic cost of breathing. I started by constructing a model of an extinct bird (wild turkey, Meleagris gallopavo); musculoskeletal anatomy was taken from CT scan and dissection data, and joint behaviour & ranges of motion were characterised using XROMM (X-ray reconstruction of moving morphology). Model predictions for muscle activation and skeletal kinematics were validated against in vivo electromyography and XROMM data, and costs of ventilation from the model fell broadly in-line with experimental results. Next, I altered the validated model to reflect morphologies seen in the early bird fossil record e.g., by removing the sternal keel or shortening the sternum posteriorly. This let me test how the morphological transformations of the ribcage and sternum associated with flight might have affected breathing mechanics along the avian stem. The evolution of a keeled sternum and increased flight muscle mass increased the cost of breathing, but other features of the ribcage acted as compensatory mechanisms, e.g., the presence of uncinate processes. Although the locomotor demands of flight on the skeleton constrain ventilation performance, birds have managed to maintain effective, low-cost ventilation even as they became increasingly specialised for flight. Integrating the results of these dynamic models with other means of reconstructing ventilation in fossils (e.g., “scientific motion transfer” of breathing kinematics from extinct archosaurs), I aim to provide a holistic view of respiratory evolution during a major ecological radiation, across the dinosaur-bird transition.

Grant Information:
This work was supported by a U.K. Biotechnology and Biological Sciences Research Council Doctoral Training Partnership (BBSRC DTP).

Technical Session XII (Friday, October 11, 2019, 8:45 AM)

BODY SIZE CORRELATES WITH DISCRETE CHARACTER MORPHOLOGICAL PROXIES IN DINOSAURS

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The application of statistical ordination techniques, primarily Principal Coordinate Analysis (PCoA), to morphology-based phylogenetic character-taxon matrices can become an increasing popular method in morphpospace and disparity studies. However, to date little effort has been invested in testing whether traits extrinsic to these matrices, such as body size, are related to the observed morphological patterns used to interpret the evolution of major body axes. We present evidence from a re-analysis of independently-compiled character-taxon matrices across a wide range of different dinosaurian clades that body size (obtained from a comprehensive database of body mass estimates) displays a previously unrecognized significant relationship with the principal axis of variation (PCoA1). Of the nine re-analysed matrices, seven returned a positive statistically significant (p<0.05) correlation between the first principal coordinate axis and body size. This correlation appears to be independent of coding strategy (i.e., contingent vs. multistate) employed in the construction of the cladistic datasets. In addition, the statistical significance of this relationship is inversely related to the size (i.e., number of characters and taxa) of the cladistic matrix. This indicates that large clades appear to be more prone to the effects of ‘hidden’ confounding factors, and that these effects may be inherent to the data used to generate morphology-based phylogenies. We extended this study to critically re-examine a recently proposed macroevolutionary hypothesis: that a strong directional shift in morphospace in the hypothetical theropod ancestors of modern birds documents a period of accelerated accumulation of avian-type traits. A re-analysis of the character-taxon matrix used to derive this hypothesis demonstrates that over 80 percent of the morphological variation along the avian stem lineage could be attributed to the reconstructed body sizes of each ancestor. Furthermore, when the effects of body size are accounted for, the strong directional change in morphology within the hypothetical avian stem lineage is effectively removed. Our results indicate that life-history traits extrinsic to character-taxon matrices can nonetheless have a significant effect on the morphological proxies derived from PCoA ordination. Future studies using PCoA-based cladistic morphospaces should therefore explore and account for potential correlations with body size to ensure that no confounding factors are influencing perceived macroevolutionary patterns.

Grant Information:
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Technical Session XII (Friday, October 11, 2019, 11:15 AM)

VARIATION IN BRAINCASE MORPHOLOGY AND PALEONEUROLOGY WITHIN CERATOPSIS.

BULLAR, Claire, University of Bristol, Bristol, United Kingdom; BENTON, Michael J., University of Bristol, Bristol, United Kingdom; ZHAO, Qi, Institute of Paleontology and Paleoanthropology, Beijing, China; RYAN, Michael, Carleton University, Ottawa, ON, Canada

In recent years the study of braincase anatomy and paleoneurology in dinosaurs and other extinct vertebrates has been transformed by high-resolution CT scanning and 3D reconstruction. The paleoneurology and development of cognitive abilities is of particular interest in Ceratopsia, a group of non-avian dinosaurs for which many behavioural theories have previously been posited. Ceratopsian braincases, however, have often been neglected because of the high level of bone fusion and consequent obscurity of internal structures. Here we use several taxa from across Ceratopsia to study morphological disparity levels in ceratopsian paleoneurological architecture. Through the examination and segmentation of high-resolution CT scans of taxa across the clade, we find that, while general braincase arrangement remained the same, the morphology of individual elements altered significantly as the group evolved. The paroccipital processes are long and thin in basal forms and become taller and distally flared to accommodate the large frills of ceratopsids. These changes also increase the area of attachment for neck muscles such as m. obliquus capitis magnus. Similarly, the basal tubera of the basioccipital grow and develop, which increases the size of neck muscle attachment sites. On the ventral surface of the braincase, the morphology and orientation of the basipterygoid processes change dramatically leading to an overall transformation in appearance of the basisphenoid. The processes project anterovertrally in basal taxa and move caudally through evolution of the clade; so that ceratopsids have caudoventrally projecting basipterygoid processes. There are some exceptions to this rule, which is possibly a result of geographic separation and allopatric speciation. On the dorsal surface of the braincase, the frontal and parietal undergo drastic change, in part due to the development and expansion of supracranial sinuses, brow horns and the parietosquamosal frill. Additionally, we explore semi-circular canal plasticity and find that there is a decrease in the size of the anterior semicircular canal relative to the posterior semicircular canal. This project has provided a suitable basis to collect synapomorphic braincase characters to complement previous phylogenetic research. In further work, these characters will be added to a grand ceratopsian phylogeny and will supplement the current sparse selection of paleoneurological characters.

Grant Information:
We thank the Paleontological Association, Geological Society of London, Neoceratopsian Scholarship, and Bristol University Alumni Foundation for funding assistance.

Preparers’ Session (Thursday, October 10, 2019, 2:45 PM)

TECHNIQUES FOR SUCCESSFUL COLLECTION OF PLEISTOCENE MEGAFAUNA MATERIAL FROM LAKE CALLABONNA FOSSIL RESERVE, SOUTH AUSTRALIA.

BURKE, Carey J., Flinders University, Adelaide, Australia; WORTHY, Trevor H., Flinders University, Adelaide, Australia; CAMENS, Aaron B., Adelaide, Australia

The Pleistocene megafauna fossil deposits of Lake Callabonna have been known for over a century. The many challenges that arise from working in this inhospitable terrain continue to test paleontologists. Fossils usually consist of articulated skeletons entombed in damp, hypersaline clays with localised concretions. There is a history of rapid deterioration of specimens after collection and aborted attempts to reach the fossil sites. The abundance and quality of fossil material at Lake Callabonna make it an enticing prospect for researchers. The integration of logistic, collection and preparation techniques will enable researchers to recover exceptional fossil material from this site.
Logistics—Lake Callabonna is extremely remote, desolate and difficult to traverse. The use of quad bikes and small ATVs to navigate the landscape is essential as standard four-wheel drive vehicles cannot access the lake surface without becoming bogged. These extra vehicles restrict the number of people and amount of supplies/equipment that can be transported to the site. The remote, desolate nature of the lake prevents supplementation of resources. Field workers require experience or training in all aspects of remote area hazards.

Collection—Standard plaster jacketing techniques are supplemented by a layer of plastic wrap within the jacket to prevent desiccation. Surrounding bones can harbour integument impressions. Multiple sites are worked simultaneously as shifting sand can make excavation impossible in some areas. Regular prospecting ensures that new skeletons are noted as they become exposed by erosion.

Preparation—Lake Callabonna fossils do not store well. Desiccating specimens results in shrinking and cracking of the dense clay matrix, destroying bone in the process. Best results are obtained while the clays are still wet. Standard mechanical removal of clay matrix followed by cleaning and consolidation with acetone and Paraloid B72 as the bones slowly dry will halt the extrusion of halite crystals from the exposed surfaces and prevent the specimen from becoming brittle. Microjacks are employed to remove localised concretions. Funding and space resources for the prompt preparation of Lake Callabonna fossil material must be considered before the expedition can proceed.

Grant Information:
ARC Discovery Project DP180101913

Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)
CHEIRACANTHUS (ACANTHODI, ACANTHODIFORMES) FROM THE MIDDLE DEVONIAN OF SCOTLAND: NEW ANATOMICAL DATA AND NEW SPECIES
BURROW, Carole, Queensland Museum, Brisbane, Australia; NEWMAN, Michael J., First Group, Johnston, Haverfordwest, United Kingdom; DEN BLAUVEN, Jan L., University of Amsterdam, Amsterdam, Netherlands

Articulated specimens of three species of Cheiracanthus, C. marchisoni, C. latus and C. grandispinus, have been known from the Orcadian Basin of northern Scotland since the mid-19th century. Although their gross morphology has been reasonably well described, the histology of much of their exo- and endoskeleton and the variation in scale morphology have not. We have addressed this lack of information by serial sectioning specimens of each species to determine the structure of scales, fin spines, and endoskeletal elements, and using scanning electron and light microscopy to examine scale morphology, fin spines, and endoskeletal elements. We can also report that other species of Cheiracanthus also occur in the Orcadian Basin, with several of these also found as isolated scales in the Baltic region. At least one new species C. peachi has been identified from both Scotland and the Baltic. The co-occurrence of the same species in both the Main Devonian Field/Baltic region and Scotland during the Middle Devonian indicates that there was at least a short-term connection between the lacustrine Orcadian Basin and the marine environment.

Symposium: Origin of a Sunburnt Country (Saturday, October 12, 2019, 11:00 AM)
FANGAROOS AND KANGAROOS: PHYLOGENY, PALEOECOLOGY, DIVERSIFICATION AND EXTINCTION OF EARLY KANGAROOS (MARSUPIALIA: MACROPODIFORMES) FROM THE RIVERSLEIGH WORLD HERITAGE AREA
BUTLER, Kaylene, The University of Queensland, St Lucia, Australia; TRAVOUILLON, Kenny, Western Australian Museum, Welspool, WA, Australia; WEISSBURGER, Vera, The University of Queensland, Brisbane, Australia; EVANS, Alistair R., Monash University, Monash University, Australia; MURPHY, Laura B., The University of Queensland, St Lucia, Australia; PRICE, Gilbert, The University of Queensland, St Lucia, Australia; ARCHER, Michael, Deakin University, New South Wales, Australia; BURTON, T., University of Queensland, Brisbane, Australia; NEWMAN, Michael J., First Group, Johnston, Haverfordwest, United Kingdom; HADEN, Suzanne J., University of New South Wales, Sydney, Australia

Kangaroos are one of Australia’s most iconic faunal groups. The suborder Macroopodiformes (kangaroos and allies) includes at least three families: Hypsiprymnodontidae (musky rat-kangaroos), Macropodidae (rat-kangaroos, kangaroos and wallabies) and an extinct family of fanged kangaroos (Balbaridae). Fossil evidence of all three families extends back to the late Oligocene. One fossil kangoaroo-bearing locality which contains numerous early representatives of all three families is the Riversleigh World Heritage Area, northwestern Queensland, Australia. Riversleigh’s numerous fossil sites which range from Oligo-Miocene to Pleistocene in age make it an ideal place to trace the evolution of kangaroos.

The timing and potential drivers behind the decline, and eventual extinction, of Balbaridae remains unresolved. Previous research suggests that, at Riversleigh, macroadpos were more diverse than balbarids throughout most of the Oligo-Miocene with balbarids becoming extinct by the end of the middle Miocene. Here, we present new data based on more recent taxonomic descriptions and analyses of species diversity, trends in body mass and skull shape. Our results indicate that macroadpos were in fact more diverse than balbarids throughout most of the Oligo-Miocene. The presence of two balbarid specimens in late Miocene deposits at Riversleigh extends the temporal range of balbarids, indicating that their extinction was more recent than previously thought.

Furthermore, previous interpretations of diet of Oligo-Miocene macroadpos (kangaroos and allies) from Riversleigh suggest that, in contrast to many modern macroadpos, distinct representatives of Macropodidae and Balbaridae were predominantly folivorous and browsers, repectively. Using principal component analysis of shape variation, Riversleigh macroadpos and balbarids generally cluster closest to extant folivorous browsers, providing support for previous interpretations of these species as browsers. Further, despite representing taxonomically distinct families, balbarids and early macroadpos exhibit similar overall cranial shapes.

Grant Information:
Research at the Riversleigh is supported by ARC grants (DE130100467, DP130100197 and DP170101420). V. Weisbecker was supported by an ARC grant (DP170103227).

Technical Session XII (Friday, October 11, 2019, 9:15 AM)
USING BIOMECHANICAL MODELLING TO INVESTIGATE AN ADAPTIVE RADIATION: A CASE STUDY IN DINOSAURIA
BUTTON, David J., Natural History Museum, London, United Kingdom; PORRO, Laura B., UCL, University College London, London, United Kingdom; JONES, Marc E., UCL, University College London, London, United Kingdom; BARRETT, Paul M., The Natural History Museum, London, United Kingdom

Adaptive radiations – rapid diversifications of clades colonizing new ecospace – are central to understanding the history of life, as they unite concepts from ecology and evolutionary theory. Information from the fossil record is critical, but paleontological studies of adaptive radiations have often been restricted to qualitative comparison of characters of presumed mechanical and ecological significance. Empirical case studies comparing direct measures of performance through clad histology have been lacking, precluding a comprehensive perspective of the dynamics of an adaptive radiation. Early dinosaur evolution, between 240–190 Ma, provide such a case study. During this interval dinosaurs greatly increased in size, diversity and abundance. Their varied craniodental morphologies have fueled hypotheses linking this radiation to innovations in the feeding apparatus and feeding ecology. However, anatomy alone can be a poor indicator of functional performance, and biomechanical studies of dinosaur crania have been restricted to deeply nested taxa. Consequently, the functional morphology and feeding behavior of early dinosaurs remains poorly understood.

Here, we virtually restore the cranial osteology of four early dinosaur taxa (Coelophysosaurus, Heterodontosaurus, Plateosaurus and Melanosaurus), including representatives of Theropoda, Ornithischia and Sauropodomorpha, from CT scan data. Scans were imported into Avizo to execute retrodeformation procedures, reconstructing taphonomic damage, and reconstruct jaw adductor musculature from osteological correlates. This then allowed the performance of finite-element analyses within Stru3D, quantifying functional performance during simulated feeding behaviors. Results demonstrate systematic differences between theropods and ornithischians consistent with early specializations towards carnivory and herbivory, with a greater emphasis on jaw closure speed versus mechanical stability, respectively. However, early sauropodomorph taxa exhibit mechanical compromises leading to more generalized performance. This suggests the rapid diversification of sauropodomorphs in the Late Triassic may have linked with dietary flexibility, rather than specialization. These data permit quantitative comparison between functional performance and diversity dynamics through the early evolution of Dinosauria, illuminating the processes underpinning an exemplar adaptive radiation.

Grant Information:
This research was supported by NERC grant NE/R000077/1, awarded to PWB and LBP.
Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)

VIRTUAL 3D-RECONSTRUCTION OF INCLUSIONS FROM THREE LARGE COPROLITES FROM AN EARLY TOURNAISSAN LAKE DEPOSIT

BYRNE, Hannah M., Uppsala University, Sweden; BLOM, Henning, Uppsala University, Sweden; NIEDZWIEDZKI, Gregorz, Uppsala University, Sweden; KEAR, Benjamin P., Uppsala University, Sweden; AHLBERG, Per E., Uppsala University, Sweden

The Devonian-Carboniferous (D-C) strata from East Greenland form one of the best successions of low latitude sediments from that time. The Obrutschev Bjerg Formation represents a deep permanent lake from the earliest Tournaisian, and this black shale deposit can be linked to the famous Hangenberg extinction event. The deposit contains an abundance of actinopterygian remains believed to belong solely to the species Cuenocephalus gardineri, along with a smaller number of acanthodian and chondrichthyan specimens. There is also an abundance of coprolites (over 100 collected of various morphologies. There are large, non-spiral coprolite present which are suspected to be tetrapod in origin, however tetrapod body fossils do not occur in this assemblage; only in the late Devonian Aina Dal and Britta Dal formations. However, large non-spiral coprolites may be tetrapod in origin, thus placing tetrapods in the vicinity of the lake. Here we present the modelled inclusions of three large coprolites, which have been imaged using Synchrotron phase-contrast microtomography at the European Synchrotron Radiation Facility (ESRF). The coprolite intrusions we were imaged using the imaging software Materialise Mimics. Both coprolites contain a similar assemblage of elements; partly articulated fish, multiple cleithra, clavicles and dental elements of actinopterygian origin, and acanthodian spines. The vast abundance of actinopterygian inclusions within the coprolites show that actinopterygians were the preferred choice of prey and could suggest that Cuenocephalus gardineri were schooling fish. It also indicates that the coprolite producer was a proficient swimmer. The actinopterygian inclusions have excellent 3D preservation, and so have the potential to aid in furthering our understanding of changes in actinopterygians across the D-C boundary.

Grant Information:
This work was supported by grants from the Wallenberg Scholarship, from the Knut and Alice Wallenberg Foundation.

Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM)

FIRST EVIDENCE OF CHAMPSAURS (DIAPSIDA: ARCHOSAURIA) FROM THE LATE CRETACEOUS OF THE ATLANTIC COASTAL PLAIN

CALLAHAN, Wayne R., New Jersey State Museum, Trenton, NJ, United States of America; MEHLING, Carl M., American Museum of Natural History, New York, NY, United States of America; BALLWANZ, Steven, New Jersey State Museum, Trenton, NJ, United States of America; DUDGEON, Thomas W., Carleton University, Ottawa, ON, Canada

Fossils recovered from the Late Cretaceous Brook Sites of Monmouth County, New Jersey have yielded a tantalizing look at the marine, nearshore, and terrestrial vertebrate fauna of Appalachia. In spite of urban sprawl and dwindling acres of natural areas, new discoveries are made on a fairly regular basis due in part to cooperative agreements between the Monmouth County Park Service and the Natural History Bureau of the New Jersey State Museum. Three vertebral centro, recovered from the Late Campanian/Early Maastrichtian boundary interval, are identified as the first reported evidence of champsosaurs from the East Coast of North America. With the exception of specimens from the Turonian/Coniacian of Axel Heiberg Island of the high Canadian Arctic, these are the only chondrosteid fossils known from Appalachia. The first of the three was recovered in-situ from the base of the Naviscink Formation along a stream bed in the area of Holmdel, New Jersey. This locality has been well studied and is interpreted as representing a mix of marine, fluvial and terrestrial environments. The other two specimens were recovered as float, along the same streambed, approximately 1.2 and 2.8 kilometers to the southeast respectively. The first of the vertebrae measures approximately 30 mm in length and 29 mm in width and height. The second is slightly smaller at 29 mm long, 25 mm in width and 22 mm in height. The third is considerably smaller at 7.5 mm long by 6 mm in width and height. All vertebrae are worn to some degree due likely to post-mortem transport. All three vertebrae are spool-shaped, with amphiplatyan to slightly amphicoelous centra. On the ventral floor of the neural canal there is a strong midline ridge, bordered laterally by hourglass-shaped longitudinal grooves characteristic of chondrosteid vertebrae. Two of the vertebrae, including the smallest, have a strong midventral keel indicative of champsosaur cervical vertebrae. Both of these also display saddle-shaped depressions where the neural arch pedicles were attached at a point slightly anterior of the mid-line of the centrum. The other specimen has a rounded ventral surface and is possibly a dorsal or proximal caudal vertebra. The ventral portion of one broken neural arch pedicle can be observed on one side of the vertebra with a clear indication of the suture. It is hoped that continued recovery of material from these localities, and a review of both institutional and private paleontological collections made from the area, will provide additional specimens of this allusive taxon in eastern North America.

Symposium: Origin of a Sunburnt Country (Saturday, October 12, 2019, 11:45 AM)

WALK LIKE A KANGAROO: NEW FOSSIL TRACKWAYS REVEAL A BIPEDALLY STRIDING MACROPODID IN THE PlioCENE OF CENTRAL AUSTRALIA

CAMENS, Aaron B., Flinders University, Adelaide, Australia; WORTHY, Trevor H., Flinders University, Adelaide, Australia

Vertebrate trace fossils can provide information relating to manual and pedal soft-tissue morphology, foraging patterns, the way in which a taxon interacts with other organisms and even novel locomotory repositories. Although Mesozoic vertebrate traces have been documented from multiple areas of Australia, Cenozoic traces have received comparatively little attention. Published sites are largely restricted to the south-eastern continental margin and are mainly of Pleistocene age. Recent investigations into the Plioocene lacustrine sediments of the Tirari Formation in the Lake Eyre Basin have revealed significant potential for the preservation of vertebrate trace fossils including flamingos, waders and large herbivorous marsupials. Here we report the discovery of two remarkable trackways in Tirari Fm. sediments (3.5-4 Ma) that appear to represent a bipedally striding kangaroo. Kangaroos are widely recognised for their hopping (ricochetal) gait and this represents the first direct evidence that any macropodid routinely employed a bipedal stride during terrestrial locomotion. The two trackways (one, 19 consecutive steps and the other, nine) both display a footprint with a single elongate digit, indicating that the track-maker was a small sthenurine kangaroo. Based on trackway parameters and species known from the skeletal fossil record for this time period, the taxon responsible was most probably either Sthenurus tindalei or a species of Archaeosimus. An analysis of the bending stresses in the tails of sthenurines for which sufficient material is known indicates that S. tindalei was using its tail differently to all other macropodids studied. The lack of tail drag marks in the trackways indicates that the tail was held off the ground and it is suggested that the track-maker employed a head-down, tail-up posture similar to that hypothesised to have been used by theropod dinosaurs. These trackways provide support for the hypothesis that some sthenurine kangaroos included bipedal striding in their locomotory repertoire and that they may not have used the pentapedal bounding seen in large extant macropodids.

Grant Information:
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Colbert Prize Poster Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)

ANALYSIS OF SOUTHERN AFRICAN PLEISTOCENE RODENT HUMERI FROM SWARTKRANS: MEMBERS 1-3

CAMPBELL, Timothy L., Texas A&M University & Baylor University, College Station, TX, United States of America; DEWITT, Thomas J., Texas A&M University, College Station, TX, United States of America; DE RUITER, Darryl J., Texas A&M University, College Station, TX, United States of America

Rodent remains found in many southern African Plio-Pleistocene fossil-bearing deposits are commonly used to reconstruct paleoenvironments using a taxonomic framework. In these studies, craniodental remains are the primary material used to reconstruct rodent paleocommunities. Postcranial elements are generally not considered. In this study, we extract the suprageneric taxonomic signal present in modern rodent humeri and apply these results to fossil specimens from the Pliocene-Senonian Swartkrans hominin-bearing sites. Members 1-3 (~2.0–0.62 Ma). High resolution images of the extensor surface of 241 modern specimens representing 5 families (Muridae, Bathyergidae, Nesomyidae, Sciuridae, Gliridae), and 126 fossil specimens were used to digitize humeral outlines. Due to sample size issues, the latter two families were grouped at the subordinal level (Sciuroidea). Outlines were then subjected to elliptic Fourier analysis from which 120 harmonic coefficients were calculated to represent shape information invariant to size, location, rotation, and outline origin. Harmonics of known specimens were then subjected to principal components (PC) analysis.
Swartkrans specimens were rotated to the PC axes as well, placing them in the same shape space as the known subjects. The 19 largest PC axes accounted for 98% of shape variance among the known specimens, and specimen scores for these variables were retained. Modern shape differences were tested using multivariate analysis of variance (MANOVA) on PC scores, and classification success was calculated using linear discriminant function analysis (LDA). Results from the LDA on modern specimens were used to classify the unknown fossil specimens. Modern specimens were found to differ strongly in shape (τ = 0.82; P < 0.01) with 91% correctly classified using posterior probabilities, and 88% using cross-validation. All misclassifications occurred between the Muridae and the Nemosyomidae families. Finally, to explore potential family level signal within the Sciuromorpha a follow-up PCA was run on modern specimens using linear measurements of humeral length and epicondylar breadth. The fossil specimens were classified to this group, and then rotated to the PC axes. Examination of the PC plot shows that the fossil specimens cluster closest to the glirids and suggests that they should be classified as such. This study demonstrates that higher level taxonomic signals are present in southern African rodent humeri, and suggests that similar studies of additional elements are warranted.

Grant Information:
Texas A&M University (Department of Anthropology - Milo E. Carlson - Vision 2020), American Society of Mammalogists, Sigma Xi, Texas Academy of Science, NSF, Leakey Foundation

Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM)
ON THE POTENTIAL TO RECONSTRUCT A DIETARY CONTINUUM IN DINOSAURS

Paleontologists of the past 200 years investigated much about the anatomy and diversity of Mesozoic dinosaurs. Dinosaur evolutionary paleoecology, however, has been particularly challenging to reconstruct, given the rarity with which direct evidence of interactions between species are preserved. For instance, dinosaur remains remain broadly categorized (herbivore vs. carnivore) and lacking in nuance. Large data sets of ecologically-relevant anatomical measures (ecometrics or functional traits) provide a means to reconstruct ecology of many species, allowing in-depth macroevolutionary studies of dietary and ecological evolution spanning the entire evolutionary history of dinosaurs. We propose the use of 3D dental surface quantification techniques to generate an ecomorphological proxy for diet. Metrics such as orientation patch count (OPCr) have already evinced their ecomorphological potential as dietary metrics in modern mammals and reptiles. These have substantial potential, but have not yet been applied to dinosaurs. Here we apply OPCr, a measure of dental complexity, to an initial data set of four phylogenetically disparate dinosaurs. Albertosaurus, Stegosaurus, Leaellynasaura, and Chasmosaurus. OPCr was calculated for individual teeth via the traditional 2.5D approach. Albertosaurus (OPCr=8) occurs near the upper extreme of modern carnivorous reptiles, due to its oval profile in occlusal view, which likely reflects the potential for bone-crushing hypothesized for tyrannosaurs. Stegosaurus (OPCr=9) occurs within a broad range of dietary values, including those of herbivorous, omnivorous, and insectivorous reptiles and it is possible that such OPCr values reflect dietary versatility among pachycephalosaurs. Both Leaellynasaura (OPCr=10.9) and Chasmosaurus (OPCr=13.9) occur well within the range of herbivorous reptiles, the latter closer to the upper extreme of all extant reptiles.

Although preliminary, these results reveal the potential of such an approach to generate a dietary continuum from dinosaur teeth spanning carnivorous to exceedingly more herbivorous ecologies. Recent attempts to reconstruct the evolution of dinosaur body size hypothesized shifts in diet as a mechanism for rapid adaptive dynamics at the origins of dinosaurs along with many tendencies towards certain adaptive body size peaks. The patterns recovered here, therefore, presents the possibility of testing the role of diet in instigating and maintaining the terrestrial dominance of dinosaurs during the Mesozoic.

Grant Information:
Australian Research Council Discovery Early Career Researcher Award (project ID: DE19010423)

Technical Session XIV (Friday, October 11, 2019, 3:45 PM)
DO FEMALE PENGUINS RESORT TO MEDULLARY BONE AS A SOURCE OF CALCIUM FOR THE EGGSHELL?
CANOVILLE, Aureole, North Carolina State University, North Carolina Museum of Natural Sciences, Raleigh, NC, United States of America; SCHWEITZER, Mary H., North Carolina State University, North Carolina Museum of Natural Sciences, Raleigh, NC, United States of America; ZANNO, Lindsay, North Carolina Museum of Natural Sciences, North Carolina State University, Raleigh, NC, United States of America

Until recently the phylogenetic distribution of medullary bone (MB), an ephemeral reservoir of calcium used by female birds for eggshell production, was largely unknown. New studies revealed that MB is widespread among Neornithes, yet it is still unclear whether this specialization is ubiquitous to all extant birds as past observations suggested that some species might resort to an alternative source for mobilizing calcium. MB has not yet been unambiguously reported in Spheniscidae, which are of particular interest to assess this question. Indeed, the dense bone microstructure of most penguins, which is an adaptation to their flightless, diving lifestyle, does not leave many voids in the medulla for the endosteal deposition of MB. Moreover, the clutch size of all penguins is small (1-2 eggs) and species laying two eggs have relatively long laying intervals. A potential calcium requirement to form eggshell is thus probably lower than in most other birds. Finally, adult penguins often exhibit cortices formed of a dense Haversian system, indicative of intense bone remodeling and mineral homeostasis. From these observations, we hypothesized that female penguin could resort in part or exclusively to the calcium contained in their thick bone cortices, without having to form large amounts of MB during egg-laying (H1). Using nano-computed-tomography (CT) and histochemical staining, we investigate the long bone microstructure of females of six penguin species that died during the egg-laying cycle, as well as conspecific males as controls, in order to test our H1 hypothesis. ii) assess whether different species resort to different sources of calcium to form eggshell (MB vs cortical bone), and iii) advance our overall understanding of MB use and phylogenetic distribution in Neornithes. Our preliminary results reveal that some species likely metabolize cortical bone tissue to form eggshell, thereby supporting H1. Indeed, a female Pygoscelis adeliae that died with an unshelled egg in its oviduct shows extensive resorption cavities throughout the hindlimb cortices, yet no signs of MB deposition. However, many-CT data and histochemical analyses suggest that some species, such as Spheniscus magellanicus and Spheniscus humboldti, deposit MB in the marrow cavity of their femur and tibiotarsus. Further analyses will be aimed at understanding the differences observed.

Grant Information:
National Science Foundation award # 1552328
American Ornithological Society Postdoctoral Research Award

Technical Session VI (Thursday, October 10, 2019, 11:45 AM)
ECOLOGICAL FUNCTION AND MACROEVOLUTIONARY PATTERNS IN PROBOSCIDEANS
CANTALAPIEDRA, Juan L., Universidad de Alcalá, Alcalá de Henares, Spain; ALBERDI, Maria Teresa, Museo Nacional de Ciencias Naturales, Madrid, Spain; PRIETO, Isabel, Universidad Nacional de La Plata, Buenos Aires, Argentina; STAANEN, Paola, Universiteit Gent, Gent, Belgium; PRADO, Jose Luis, Universidad Nacional del Centro de la Provincia de Buenos Aires (UNICEN), Buenos Aires, Argentina; ZHANG, Hanwen, University of Bristol, Bristol, United Kingdom; SANISIDRO, Oscar, University of Kansas, Lawrence, KS, United States of America; BLANCO, Fernando, Museo für Naturkunde, Berlin, Germany; SAARINEN, Juha, University of Helsinki, Helsinki, Finland

With only three living species, today’s proboscideans represent a tiny fraction of their Cenozoic diversity. During their 60 myr of evolution, proboscideans dispersed over Africa, Eurasia and America, they evolved into remarkable diversity of body sizes and dental adaptations, and have been common constituents of Cenozoic mammalian communities. Which factors drove the richness fall of this iconic lineage? Despite their cosmopolitanism and relevant ecological role (most of the largest Cenozoic terrestrial mammals were proboscideans), we lack comprehensive quantitative approaches that assess the large-scale processes that shaped their diversity trends: speciation, extinction and the potential role of ecological adaptation in species selection. We present preliminary results based on an up-to-date comprehensive database of proboscideans that includes 2300 occurrences for 196 species, and 12 ecomorphological traits. The early proboscides fossil record (57 to 40 Ma) is scarce, and yet we recover the signal of a sustained high turnover during this interval (high speciation and extinction). From 40 to 2.5 Ma the clade shows a steady increase in diversity rendered by an overall-constant, moderate net diversification (0.1 species Myr-1). In the earliest Miocene we
recover a sudden increase in ecological disparity, which has plateaued out since then, though diversity and ecomorphs increase through the Neogene. Neogene, these new ecomorphs do not represent large innovations, being added to already-opened regions of the ecological space. The diversity trend peaks in the early Pleistocene, when we estimate a global species richness of around 30 species. Speciation through the Neogene was mainly clustered in the ecological space, whereas extinction has shifted in its ecological scope, being generally clustered within ecological niches until Pleistocene times. Since 15 to 6 Ma, the increase in functional diversity, which may have fueled the steady net diversification rates, was maintained at the expense of increasing functional vulnerability (higher frequency of unique ecomorphs). The Pleistocene, specifically the last 1.5 myr, brought about a very severe extinction pulse that hit a wide array of ecological niches, wiping off two thirds of the species by the end of this period and a significant part of the functional disparity too.

Grant Information:
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Regular Poster Session I (Wednesday, October 9, 2019, 4:15 - 6:15 PM)

ECOLOGICAL NICHES AMONG PTEROSAURS FROM THE SOLNHOFEN ARCHIPELAGO

CARDozo, Filipe G., University. Fed. Espirito Santo, Vitoria, Brazil; SOBRAl, Gabriela, Staatliches Museum für Naturkunde Stuttgart, Stuttgart, Germany; RODRIGUEZ, Taissa, University. Fed. Espirito Santo, Vitoria, Brazil

The Solnhofen Limestones of southern Germany are one of the most important deposits for studying pterosaurs, and the most relevant Jurassic one in terms of diversity, disparity, and abundance. Recent taxonomic reviews suggest that up to twelve genera of pterosaurs might have been present there. Even though many have been recovered from different chronostratigraphic units, the high taxonomic diversity and morphological disparity still suggest specializations that reflect distinct ecological roles. An endocast analysis of *Pterodactylus antiquus*, together with a literature review of the anatomy and ecology of these taxa, suggest interesting niche partitions. *Pterodactylus, Scaphognathus, and Rhamphorhynchus* were generalist taxa that lived on coastal areas and fed on fishes and small invertebrates. Their niche, however, did not overlap completely: our analysis corroborates a previous study that *Pterodactylus* had photopic vision, in contrast to the scopic type of *Rhamphorhynchus*. *Scaphognathus* was also photopic, but the different dentition indicates it was not preying on the same items as *Pterodactylus*. Other taxa have been regarded as more specialists. *Germanodactylus* has been proposed as a daphogue, based mostly on the lack of teeth on the tips of the rostrum and mandible, and therefore also likely preyed on different items than *Pterodactylus*. *Anurognathus, Ctenochasma, Gnathosaurus, and Cycnorhamphus* represent highly specialized taxa. *Anurognathus* was probably an aerial insectivore, with moderately curved unguals that are consistent with a scavenging habitat, thus suggesting it inhabited forested areas. *Ctenochasma* and *Gnathosaurus* were filter feeders and their different sizes might have prevented, at least to some extent, niche overlap. The diet of *Cycnorhamphus* is more disputed: it has been proposed as a daphogue, a jaguarish pterosaur for a generalist feeding ecology with its uniquely curved mandible with teeth only on the distal tip implies a different feeding niche from Solnhofen generalist pterosaurs. Lastly, the endocast of *Diepechopterus kochi*, a taxon that has been proposed as synonomy with *Pterodactylus*, was analyzed but poor preservation prevented adequate assumptions on niche specializations. Our preliminary analyses suggest that, although the Solnhofen archipelago was a rich pterosaur site, these taxa were not in direct competition, separated either by functional anatomy or time. More data on paleoneurology is still needed to better understand niche occupation by *Pterodactylus*.

Grant Information:
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Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)

BIRDS OF A FEATHER: CALAMUS CORROBORATES IDENTITY OF ARCHAEOPTERYX WING COVERT

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Previously, we reinterpreted the iconic fossil feather (MB.Av.100) as an upper major primary covert, based on the relatively long calamus originally present. A recent study has confirmed the existence and morphology of this calamus, implicitly corroborating our identification of the Jurassic "Triceratops." Nonetheless, that study challenged the feather's identity, based on a lack of an S-shaped centerline purportedly observed for the first time in upper major primary coverts of some modern birds. However, there are errors in the results presented, and the interpretations conflict the feather's and archosaur taxonomic identities. Here we present further evidence that the feather is a primary covert, based on seven morphological characteristics. Critically, this hypothesis is independently supported by evidence of similar primary coverts in multiple fossils of *Archaeopteryx*, particularly the 11th Berlin, London, and fossil feather, we will never know the anatomical and taxonomic provenance with 100% certainty. However, based on the positive evidence herein, the most empirical and parsimonious conclusion is that the feather represents a primary covert from the ancient wing of *Archaeopteryx*.

Regular Poster Session III (Friday, October 11, 2019, 4:15 - 6:15 PM)

NEW CENTROSAURINE CERATOPSIANS FROM THE CAMPANIAN WAWHEWP FORMATION OF UTAH

CARPENTER, Savannah R., University of Utah, Centerville, UT, United States of America; LOEWEN, Mark A., University of Utah, Salt Lake City, UT, United States of America; CHIBA, Kentaro, Okayama, Japan; LUND, Eric K., Heritage College of Osteopathic Medicine, Athens, OH, United States of America; ROBERTS, Eric M., James Cook University, Townsville, Australia

Two centrosaurine ceratopsids extend the range of centrosaurans from bottom to the top of the Campanian Wawweap Formation of southern Utah’s Grand Staircase-Escalante National Monument. Previously named centrosaurine ceratopsians from the Wawweap Formation include *Diabloceratops eatoni* from the middle member and *Machaiaurascornus eatoni* from the upper member. UMNH VP 20600 was recovered from the lower member of the Wawweap Formation below a bentonite horizon dated to 80.6 Ma (although new U/Pb dating suggests that this bentonite may be considerably older) and represents the oldest centrosapid from Utah. It is represented by vertebrae and portions of a unique parietosquamosal frill characterized by a broad M-shaped parietal with two laterally curved epiparietals (ep1) that lie in the plane of the frill on either side of a medium embayment. The flat, blade-like epiparietals differ from the rounded shape of the ep1 in both Machaiasceratops and *Diabloceratops*. There is no evidence of any other epiparietals on the parietal, a condition it shares only with *Machaiaurascornus*. UMNH VP 9549 was recovered from the very top of the upper member on a deflation surface below the capping sandstone of the Wawweap Formation, which is not older than ~77 Ma based on U/Pb dating of detrital zircons in this unit. It consists of some postcranial material and includes the margins of a round parietal with distinct scalloped nodes with attachment scars for epiparietals ep1 through ep6. The scallops are imbricated and all are oriented in the plane of the frill. There is a dorsal groove paralleling the lateral margin of the frill that disappears posteriorly and a corresponding ventral groove on the distmedial portion of the frill that is unique amongst Centrosaurina. These two distinctive features extend the range of centrosaurs that lived within the Wawweap Formation and combined with *Xantoceratops* and a second Kaiparowits Formation centrosaur illustrate a unique assemblage of 6 distinct centrosaurs broadly between 82 Ma and 75 Ma in southern Utah.

Technical Session XVII (Saturday, October 12, 2019, 9:15 AM)

SIZE AND MASS DON'T COVARY WITH MATURITY AMONG ADULT SPECIMENS OF TYNANNOSAURUS REX

CARR, Thomas D., Carthage College, Kenosha, WI, United States of America

A recent report of a large and massive adult *Tyannosaurus rex* (RSM 2523.8) draws attention to the use of size and mass proxies for maturity of extant archosaurs, such as crocodylians. The hypotheses that size and mass are accurate proxies for maturity in *T. rex* was tested through a Spearmann rank correlation of the 2537 steps,
a CI of 0.69, an HI of 0.31, an RI of 0.75, and an RC of 0.53. The topology is
equicnent and linear, with two side branches that include multiple
specimens, which represent oversampled growth stages. The ontogram is
composed of 16 growth stages, and all but the first are supported by
unambiguously optimized synontomorphies. An analysis that
included an artificial adult, which was coded based on the optimizations from
the initial analysis, identified FMNH PR2081 as the most mature specimen in
the sample. In contrast, the massive RSM 2523.8 was recovered as the least
mature adult. The sole unambiguous female specimen (MOR 1125), based on
the presence of femoral medullary bone, was recovered as the least mature
young adult. Therefore, there is no skeletalontological evidence for sexual
dimorphism in the data set. Comparison of the ontogram with a previously
published growth curve for T. rex permits the diagnosis of five discrete higher-
level growth categories, namely juvenile, subadult, young adult, adult, and
senescent adult. Scatterplots show that size and mass are congruent with maturity until
adulthood, and thereafter no pattern is seen. Statistically significant \( r_s \)
coefficients were almost always not seen (e.g., size \( p = 0.8, \ mass, p = 0.5 \)), indicating a lack of correlation. Ergo, the evidence shows
that size and mass are useful estimates of maturity in the juvenile and subadult
growth categories, but not in later growth stages.

Technical Session XVII (Saturday, October 12, 2019, 9:00 AM)
NEW INSIGHTS INTO ALLOSAUROUS FRAGILIS MARSCH, 1877 (DINOSAURIA, TEROPODA) FROM THE TOPOTYPE SPECIMEN, USNM 4734
CARRANO, Matthew T., Smithsonian Institution National Museum of
Natural History, Washington, DC, United States of America; LOEWEN, Mark A., University of Utah, Salt Lake City, UT, United States of America; EVERS, Serjoscha W., Fribourg, Switzerland
USNM 4734 was collected from the Marsh-Felch Quarry in the Morrison
Formation near Garden Park, Colorado in 1883–1884 by M. P. Felch, working
for Yale University’s O. C. Marsh. Eventually transferred to the Smithsonian Institution by the specimen was later described in detail by Charles Gilmore (1920) along with other theropod material from that quarry. As one of a small number of nearly complete individuals of Allosaurus fragilis, USNM 4734 has served as a benchmark for this important Late Jurassic theropod taxon for almost a century. But Gilmore’s work, while thorough, was made when very few other theropods were available for comparison, and some important anatomical features (such as the furcula) were not described in detail. Furthermore, the skull has been on exhibit since 1916, and the remainder of the specimen since 1981, making further study difficult.
The recent renovation of the Smithsonian’s Fossil Halls has allowed us to
study USNM 4734 in detail, dismantled and completely free of armature, prior
to its reinstallation. Digital mirror-imaging of missing elements was essential in resolving some issues of articulation. A full re-description is underway, but several key aspects are already apparent.
First, we can settle the long-standing debate about the skull of USNM 4734
and the putative existence of a “short-snouted allosaur” in the Morrison. Gilmore had few complete Allosaurus skulls for comparison, and the damage
and deformation suffered by USNM 4734 resulted in a telescoping of the
facial region. This gave the erroneous impression of a blunt rostrum; disassembly of the skull revealed that its proportions conform well to those of other Allosaurus individuals. Later workers have suggested that the right
premaxilla was too small and belonged to a different individual. However, it
articulates properly with the (mirror-imaged) right maxilla and clearly belongs
to this specimen.
The rear of the skull agrees well with the morphology exhibited by other
specimens assigned to A. fragilis (e.g., those from the Cleveland-Lloyd Quarry), rather than those identified as A. jimmadseni. The furcula is consistent with those of other Allosaurus specimens, with a broad interclavicular angle and a very small ventral tuber. Discrete, circular
anatomical features appear to be present along the neural spine bases of the posterior sacrals, as well as within the anterior end of the brevis fossa. These and other newly observed anatomical details will be crucial to deciphering the relationships between the three named species of Allosaurus.

Grant Information:
Smithsonian Institution MacMillan Fund

Technical Session XVII (Saturday, October 12, 2019, 11:30 AM)
A COPROLITE-PRESERVED FEATHER ASSEMBLAGE FROM THE UPPER CRETACEOUS HELL CREEK FORMATION
CARROLL, Nathan, University of Southern California, Los Angeles, CA, United States of America; WILSON, Gregory P., University of Washington, Seattle, WA, United States of America; DEMAR, David G., National Museum of Natural History Smithsonian Institution, Washington, DC, DC, United States of America; CHIAPPE, Luis M., Natural History Museum of Los Angeles County, Los Angeles, CA, United States of America
The rarity of three-dimensional (3D) fossil feather preservation the Mesozoic,
particularly in the Late Cretaceous, has historically hindered direct fossil
comparison with many aspects of extant bird feathers. We report a feather
assemblage displaying the earliest record of modern avian feather structures
in a phosphatic coprolite fragment from the Upper Cretaceous Hell Creek
Formation, northeastern Montana, U.S.A. Observations of the coprolite surface with optical and scanning electron microscopy (SEM) reveal the
preservation of multiple partial avian feathers and bones with likely avian
affinity. Despite digestive taphonomic effects including mechanical breakage
and selective biodegradation, preservation of 3D macro to nanoscale feather
structures can be observed. These features include a central shaft that transitions from a proximal hollow calamus that transitions to a square/rectangular pith-filled rachis, barbs with pith-filled rami, and fibers
within the barbules, rami, and rachis cortex; features so far only recorded from
modern flying birds. SEM analysis revealed elongate, striated fibers (~5–8
microns in diameter) that are aligned in various orientations along the rachis and barb cortices. X-ray fluorescence analysis of coprolite matrix and feather structures suggest a combination of selective biodegradation and multiphase phosphate replacement. This preservation pathway results in clear density contrasts between feather morphologies and surrounding coprolite matrix, allowing for high-fidelity 3D reconstructions of feather inclusions from x-ray computed microtomographic (micro-CT) scans. 3D imaging reveals approximately 20 partial feather rachis inclusions and a relatively complete contour feather with matching morphologies to the superficially exposed feather. The mainly longitudinally aligned feather and bone inclusions, partial
digestion of bones, and coprolite diameter (~7 cm) suggests a large carnivore was the producer, likely a large crocodilian or tyrannosaur. The integration of a range of analytical and imaging techniques applied to a traditionally under-
sampled fossil resource allowed for an exceptional view into the evolution of
the complex, hierarchal, fiber-reinforced composite construction of the
modern bird feather.

Regular Poster Session III (Friday, October 11, 2019, 4:15 - 6:15 PM)
AN ASSOCIATED ORNITHOPOD DINOSAUR HIND LIMB FROM THE UPPERMOST CRETACEOUS (MAASTRICHTIAN) LOPEZ DE BERTODANO FORMATION OF THE JAMES ROSS BASIN, WEST ANTARCTICA
CASE, Judd A., Eastern Washington University, Cheney, WA, United States of America; LAAMANNA, Matthew C., Carnegie Museum of Natural History, Pittsburgh, PA, United States of America; ELY, Ricardo C., Indiana University, Bloomington, IN, United States of America
In 2005, one of us (JAC) collected fragmentary but closely associated distal
hind limb elements (proximal ischium, right proximal tibia, and right proximal
metatarsal IV) of a non-avian dinosaur were collected from the Maastrichtian Sandwich Bluff Mbr of the López de Bertodano Fm on Vega Island, in the James Ross Basin (JRB) of the Antarctic Peninsula. The specimen was collected from the base of the ‘Reptile Horizon’, which has also yielded other remains (ankylosaur ossaosteo, hadrosaur tooth and avian bones), and is the
statiographically youngest associated dinosaur fossil yet recovered from
Antarctica. The new hind limb pertains to a medium-sized, non
hadrosauriform ornithopod that is larger than the two described elasmarian ornithopods from the Snow Hill Island Fm: Morrosaurus from the Maastrichtian Cape Lamb Mbr and Triniasaura from the CampanianGamma Mbr.
The new specimen displays a suite of unusual features not seen in other
Cretaceous ornithopods from Antarctica or South America: (1) metatarsals II and IV with proximal articular surfaces that are large, comma-shaped, and
mirror images of one another; (2) a planar proximal articular surface that
extends across metatarsals II–IV; (3) metatarsal IV with significant lateral
constriction from the broad proximal to the diaphysis; (4) flat proximal articular surfaces between metatarsals II/III and III/IV (in many other
ornithopods, a process on metatarsal III articulates with a notch on metatarsal IV).

Morphometric analyses of metatarsal IV dimensions place the new specimen
within Dryosauridae, the metatarsal IV proportions are statistically distinct
from those of both elasmarians and other iguanodontians. Phylogenetic
analyses based on pedal characters also place the new Antarctic fossil within Dryosauridae (as the sister taxon of Eousdryosaurus), but there is virtually no bootstrap support for any of the recovered topologies. With Morrosaurus, Trinisaura, and the hadrosaurid, the new hind limb adds a probable fourth ornithopod taxon to the latest Cretaceous non-avian dinosaur fauna of Antarctica. Coupled with the rarity of sauropods—so far known only from a caudal centrum from the Gamma Member—the apparent prevalence of ornithopods in the JRB is consistent with the predominance of these ornithischians that is seen in other high-latitude Gondwanan Cretaceous ecosystems (e.g., those of southern Australia).

Grant Information:
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MCL research participation supported by US National Science Foundation grant ANT-1142129.

Technical Session X (Friday, October 11, 2019, 11:00 AM)
INVESTIGATION OF THE EVOLUTIONARY SUCCESS AND EXTINCTION OF PYNODONT FISHES USING QUANTITATIVE METHODS
Cawley, John J., University of Vienna, Vienna, Austria; MARRAMA, Giuseppe, University of Vienna, Vienna, Austria; CARNEVALE, Giorgio, Università degli Studi di Torino, Turin, Italy; KRIWET, Jürgen, University of Vienna, Vienna, Austria

Pycnodont fishes (Pycnodontiformes) were an ecologically successful clade of predominantly quadrupeled herbivorous dinosaurs that dominated many Mesozoic terrestrial ecosystems. Several potential peaks and troughs in their diversity have previously been identified. However, spatiotemporal changes in fossil specimen completeness can bias our understanding of their evolutionary history. The quality of the sauropodomorph fossil record was previously assessed a decade ago, but the number of valid species has since increased by a third, and a third of the species from that study have undergone revision. Here, we assess how 10 years of additional research has changed our outlook on the sauropodomorph fossil record. We quantified the completeness of all 307 sauropodomorph species currently considered valid, using the skeletal completeness metric (SCM), which calculates the proportion of a complete skeleton preserved for each taxon. Mean average SCM scores were calculated for each stage of the Mesoic to produce a time series. This was statistically compared to species richness and sampling proxies through geological time, with further analyses evaluating variation between different geographical localities, depositional environments, taxonomic and body size subgroups, and against other tetrapod groups. Similarly, to the previous assessment we find non-neosauropods still have significantly more complete record than Neosauropoda, with basal sauropodomorphs having the most complete record and titanosaurs the least. However, we find no significant evidence of a phylogenetic signal for completeness. Completeness also seems to be unrelated to species’ body size, even when considering their phylogenetic relationships, and seems relatively unaffected by preservation in different depositional environments or continents, plus has a similar spread of latitudinal occurrences in both hemispheres. However, new temporal patterns in mean completeness reveal peaks in the Early and Middle Jurassic, and now a significant drop in the Late Jurassic, Cretaceous. This record is strongly influenced by taxonomic and stratigraphic age revisions as there is a significant difference with results from the previous assessment, but no statistical difference with the pre-2010 and pre-2000 time series created from our revised data. Completeness still significantly correlates with species richness through time, but also correlates with the theropod dinosaur SCM, possibly indicating that both records are primarily driven by the same sampling biases.

Grant Information:
European Union's Horizon 2020 research and innovation programme 2014–2018 under grant agreement 637483 (ERC Starting Grant TERRA)

Regular Poster Session I (Wednesday, October 9, 2019, 4:15 - 6:15 PM)
ACCOUNTING FOR PHYLOGENETIC AND TEMPORAL CONFLICT AMONG ANATOMICAL PARTITIONS IDENTIFIES AN END-TRIASSIC ORIGIN OF CROWN MAMMALS
Celik, Melina, Queensland University of Technology, Brisbane, Australia; Phillips, Matthew J., Queensland University of Technology, Brisbane, Australia

The evolutionary history of Mesozoic mammaliaforms and timing of their radiation is well-studied, yet still poorly resolved. Even though functional and developmental covariation has long been identified as an important source of phylogenetic error, lumping incongruent morphological characters altogether is current practice when reconstructing phylogenetic relationships among extinct taxa. This has strong implications for the placement of taxa, such as australopiths, haramiyids and multituberculates, but even the taxonomic definition and temporal origin of the mammalian crown group. Based on prior hypotheses and homology analysis, we identified and excluded character complexes anticipated to introduce phylogenetic error (correlated homoplastic characters), and improved confidence in tree topology. Integrating morphological and molecular data in a tip- and node-dating analysis improved precision and confirmed an origin of crown mammals close to the Triassic-Jurassic boundary, followed by a rapid diversification of stem lineages of most major Mesozoic mammal clades. In addition, ancestral state reconstructions suggest parallel evolution of key mammalian innovations, often associated with the initial acquisition of endothermy. Therefore, our results strongly emphasize the Triassic-Jurassic boundary as similarly important to the Cretaceous-Paleogene event for the mammalian diversification.

Grant Information:
Australian Research Council Discovery Projects

Regular Poster Session III (Friday, October 11, 2019, 4:15 - 6:15 PM)
NEW REMINGTONOCETID MATERIAL FROM MIDDLE EOCENE OF KUTCHE, INDIA
Chakraborty, Sreemoyee, Indian Statistical Institute, North 24 Parganas, India

The pericratonic Kutch Basin lies in the Western part of India with a continuous succession of Cenozoic marine sediments which have yielded and are still yielding many important vertebrate fossils, among which whales are most common. Recently a nearly complete skull of a whale has been recovered from the Middle Eocene Harudi Formation. The skull belongs to...
the genus *Remingtonocetus* having the length of approximately 80 cm. Like other Remingtonocetids, the skull is long and narrow with the external nare located on the front. It has narrow frontal shields, small orbits, a convex palate and dental formula 3.1.4.3. The nasal bones are elongate with reduced frontals. Position of the external nare, shape of the skull, elongation of the rostrum and dentition indicates its similarity with *R. harudiensis*. However, there are some characters observed to be different from *R. harudiensis* and *R. slouani*. The fossil specimen consists of teeth with well-preserved enamel and serrations on the edges of the teeth. The dental formula follows the pattern 11-2-3: C1, P1-2-3-4, M1-2-3. Diastema between the incisors is 10 cm approximately but the diastema between the last Incisor and Canine is 22.85 mm which is larger than described previously. The diastema between P1 and P2 is 39.02 mm which is again more than *R. harudiensis*. The diastema between P3 and P4 is very low - 2.96 mm and the teeth from P4 to M3 are juxtaposed with each other. The dental plate of the new specimen is 43.5 cm, which is larger than the previously described specimens of *R. harudiensis*. On closer observations the teeth showed sufficient wear and tear, particularly in the canine. The external nares, as stated in previous literatures, are not above the canine. In all the individuals, it is actually positioned between the C1 and P 4. Hence, this new specimen shows variations within a single species noted from Harudi. Over and above, the rich remingtonocetid fauna of Harudi show high disparity and low diversity. The new skull was collected from brown mudstones that sometimes has a greenish hue due to the presence of glauconite. The horizon, from where the skull is collected occurs just above a coquina bed and consist of foraminifera (*Nummulites*) and echinoids. Glauconitic shale, forminiferal facies and the whales suggest open marine setting. They are restricted in the warmer climate of Middle Eocene time and thrived in near shore to open marine conditions.

**Technical Session XII (Friday, October 11, 2019, 10:30 AM)**

### INTRASKELETAL VARIATION IN MASSOSPONDYLUS CARINATUS: IMPLICATIONS FOR ONTOGENY

**CHAPELLE, Kimberley E.**, University of the Witwatersrand, Johannesburg, South Africa; **BOTHA-BRINDLE, Jennifer**, National Museum, Bloemfontein, South Africa; **CHOINIERE, Jonah N.**, University of the Witwatersrand, Johannesburg, South Africa

*Massospondylus carinatus* is an iconic basal sauropodomorph dinosaur from southern Africa that lived during the Early Jurassic following the end-Triassic mass extinction (ETE). It has previously been hypothesised that *M. carinatus* underwent a postural shift from quadrupedal to bipedal during ontogeny. Understanding ontogenetic changes in locomotory trajectories is important for comprehending the macroevolutionary patterns of posture in Dinosauria. We compare the forelimb and hindlimb osteohistology of an ontogenetic series comprising 15 *M. carinatus* specimens. We hypothesise that a postural shift would be recorded in the bone tissue and discernable through inter-elemental differences in tissue organisation or growth rates between the fore- and hind-limb. Our findings confirm the results of previous studies on *M. carinatus* in finding that cyclic fibrolamellar bone is the predominant bone tissue pattern during early and mid-ontogeny. We find a transition to slower-forming parallel-fibred bone during late ontogeny. Using lines of arrested growth (LAGs) circumferences as a proxy of body mass in a complete series of femora, we refute a sigmoidal growth model in *M. carinatus*, instead supporting a constant-rate growth model. The bone tissue is interrupted by irregularly spaced LAGs, indicating temporary cessations in growth. Several elements contain multiple LAGs at various ontogenetic stages, with little consistency between element or stage. These features suggest the presence of developmental plasticity, which may have been a response to the unstable environmental conditions of the Early Jurassic. Although inter-elemental variability is present, propodial elements growing faster than epipodials, there are no notable differences in growth pattern or rate between the humerus and femur. This suggests that either there was no shift in posture or that osteohistology does not record changes in locomotory trajectories.

**Grant Information:**

Indian Statistical Institute

### TOTAL-EVIDENCE FRAMEWORK REVEALS COMPLEX MORPHOLOGICAL EVOLUTION AND RAPID EVOLUTION IN NONBIRDS (STRISEANS)

**CHEN, Albert**, University of Bath, Bath, United Kingdom; **WHITE, Noor D.**, National Institutes of Health, Bethesda, MD, United States of America; **BENSON, Roger**, University of Oxford, Oxford, United Kingdom; **BRAUN, Michael J.**, National Museum of Natural History, Washington, DC, United States of America; **FIELD, Daniel**, University of Cambridge, Cambridge, United Kingdom

Strisores is a clade of often inverteorous neotherian birds that includes specialized fliers such as swifts and hummingbirds, as well as a large diversity of nocturnal species such as nightjars. Despite the use of large-scale molecular datasets, the precise phylogenetic relationships among major strisorean groups remain controversial. Given the lack of consensus among recent phylogenomic datasets, we incorporated anatomical data from living and fossil strisoreans into a Bayesian total-evidence framework. This combined analysis of molecular and morphological data resulted in a phylogenetic topology for Strisores that is congruent with the findings of a recent molecular phylogenomic study of modern birds. However, we found that integration of molecular and morphological data did not yield increased statistical confidence in our topology, highlighting apparent homoplasy in both sequence and anatomical data. We suggest that disparate strisorean lineages have experienced convergent evolution across the skeleton, and that many of the distinctive specializations of strisorean subclades were acquired early in their evolutionary history. Furthermore, the results of applying tip-dating methods to this dataset indicate very rapid diversification of major strisorean lineages shortly following the origin of this clade. These complex patterns have resulted in a challenging phylogenetic problem, which obfuscates the robust inference of ancestral character states.

**Grant Information:**

This research was supported by a grant from the Systematics Research Fund.
This complicated structure of pterygoid and ectopterygoid can only be observed in the dorsal view of palatal complex, and it consists with the situation in some previous studies. The ectopterygoids in <i>Hongshantopus, Kunpengopterus, Caupedactylus, Tupuxuara, and Anhangua</i> overlay dorsally the pterygoids as well. Our study indicates that this complex structure probably exists in <i>Gnathosaurus, Dzangaripiterus, Troposgnathus, and Coloborhynchos</i> with comparing with <i>Hampterus, Caupedactylus, and Anhangua</i>. Thus, we assume that the ectopterygoid extend across the pterygoid dorsally very early, at least in <i>Kunpengopterus</i>, and that this situation probably is a synapomorphy in the Monofenestrae.

**Grant Information:**
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NEW INSIGHTS ON THE EVOLUTION OF NECERATOPSIAN FRILL: ORNAMENTATIONS ON <i>PROTOCERATOPS</i>

Numerous specimens of the neoceratopsian dinosaur <i>Protoceratops</i> have been collected from the Gobi Desert. Based on this plethora of specimens, the biology of the dinosaur, such as ontogenetic changes and individual variation, has been repeatedly investigated. This dinosaur has a developed frill composed of a parietal and squamosal, but it is generally thought that the frill margin is smooth and unornamented, unlike ceratopsid dinosaurs. There is a report of a <i>Protoceratops andrewsi</i> specimen with an undulated frill margin, but its importance in reconstructing the evolution of neoceratopsian frill ornamentations has been overlooked.

We re-examined over fifty <i>Protoceratops</i> specimens and found at least three additional specimens with undulated frill margins. Among these four specimens from Mongolia (two <i>P. andrewsi</i> from Bayn Dzak, one <i>P. andrewsi</i> from Tugrikin Shire, and one <i>Protoceratops</i> sp. from Udyon Sayr), there are five undulations that are inconsistently spaced along each side of the frill margin. In addition, the location of each undulation is not consistent between specimens. The skull sizes of these specimens range from small (total skull length ca. 250 mm and frill width ca. 135 mm) to large (frill width ca. 600 mm) indicating that the degree of undulation is not correlated to skull size. The undulations of the smallest and the largest specimen are imbricated, which is typical for centrosaurine frill margins, but not for chaomasiine. Unlike ceratopsid dinosaurs, there is no sign of epimarginal attachment on the undulations, although these undulations are typically equated with the eventual ontogenetic development of epimarginals in ceratopsids.

This study highlights the variability of frill margin undulations in <i>Protoceratops</i>, which are independent of ontogeny, and a pattern that contrasts with ceratopsids. It is still debated whether or not the evolution of frill ornamentations in ceratopsid dinosaurs were driven by sexual selection, but the pattern seen in <i>Protoceratops</i> frill margins suggests that sexual selection was not the primary driver. The current parsimonious interpretation for the presence of frill margin undulations in <i>Protoceratops</i> and ceratopsids is individual acquisition of the character in each clade. However, this case study implies that further investigations may reveal the presence of frill margin undulations and imbrications in other non-ceratopsid neoceratopsian dinosaurs and that frill margin undulation may have originated earlier in their evolution than previously thought.

**Grant Information:**
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**Symposium:** From Molecules to Macroevolution (Wednesday, October 9, 2019, 11:30 AM)

THE COMPLEX TAPHONOMIC HISTORY OF ORGANIC TISSUES WITHIN LITHIFIED COPROLITES

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Most fossilized vertebrate soft tissues are found in association with articulated carcases or have been extracted from skeletal materials. In contrast, labile tissues preserved within coprolites offer complementary perspectives on vertebrate paleobiology through evidence of interactions with other ancient organisms. However, the taphonomic pathway to fossilization of feces is complex, and quality of preservation varies widely among different coprolite specimens. Much of this variation reflects that fecal contents are determined by food selection and digestive physiology. Physical and chemical digestion processes before undigested food residues are packaged in feces with gut bacteria and other materials. The high percentages of bacteria in fecal matter are relevant to fossilization potential because of the capacity of some bacteria to precipitate mineralized matrix slows processes of degradation. Yet, this protection may be eroded through permineralization with allochthonous minerals. Regardless of taphonomic pathway, rapid entombment of fecal matter within a mineralized matrix slows processes of degradation. For this reason, the protection may not last in dynamic geological settings, where recrystallization and other forms of late stage diagenesis can eventually destroy even refractory inclusions. Nevertheless, coprolites lithified in relatively stable environments can retain a variety of soft tissues preserved through different modes of fossilization. A growing number of studies have identified organic structures originally composed of chitin, keratin, cutin, collagen, and other materials in lithified coprolites. Organic compounds in the form of lipid biomarkers have also been extracted from mineralized coprolites, including glycerol dialkyl glycerol tetraethers (GDGTs). In other cases, detailed casts reveal the morphology of labile tissues replaced by authigenic minerals. These multimodal forms of soft tissue preservation offer insights on ancient feeding habits, nutrient recycling, trophic interactions, and paleoenvironments.

Technical Session V (Wednesday, October 9, 2019, 1:45 PM)

GROWTH STRATEGIES LINKED TO PREVAILING ENVIRONMENTAL CONDITIONS IN AUSTRALIAN GIANT FLIGHTLESS MIRHIRUNG BIRDS (AVES: DROMORHITIDAE)

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The dromornithids were giant flightless birds endemic to Australia. They are known from the late Paleogene to the late Pleistocene and are represented by eight species in four genera. Here we focus on the largest known dromornithid, and among the heaviest birds (about 610 kg), the late Miocene aged Dromornis stictor; and the medium sized Genyornis newtoni that probably weighed about 250 Kg. Genyornis is the youngest member of the dromornithid family and became extinct about 40,000 years ago. Since little is known about the biology of these birds, we undertook a detailed investigation of their bones to deduce various aspects of their life history. This study focuses on four tibiotarsi, two tarsometatarsi and a femur of Genyornis that were recovered from the dry desert region of Australia. In addition, we expanded our previous osteohistology sample by including additional younger and adult specimens of Dromornis from the late Miocene Alcoota Local Fauna in the Northern Territory of Australia. The bone histology of Dromornis and Genyornis show that these birds experienced a cyclical pattern of growth with alternating rapid and slower rates of osteogenesis. During faster periods of growth they deposited fibrolamellar bone tissue, whilst during periods of slowed growth they formed lamellar bone tissue, which was sometimes associated with lines of arrested growth indicating pauses in osteogenesis and growth. However, we found that these birds differed in the amount of time taken to grow to maturity: Dromornis has over 10 growth cycles while Genyornis shows a maximum of 3 growth cycles. Interestingly, in Genyornis some of the lamellar deposits are wide, indicating that they grew slowly for longer periods of time. The main aridification of Australia is considered to have occurred from the late Miocene through to the Pleistocene. We postulate that the growth dynamics of the dromornithids were adapted to the particular environment in which they lived, i.e., Dromornis lived before the main aridification and therefore a k-selected lifestyle strategy would have been advantageous. However, as landscape resources became less predictable, then r-selected strategies were favoured by Genyornis. The wide bands of lamellar bone in some of the Genyornis samples may have been subject with lengthy stressful periods (drought).

Grant Information: ARC Discovery Project Grant, DP180101913

Regular Poster Session III (Friday, October 11, 2019, 4:15 - 6:15 PM)

DETERMINING AUSTRALIAN Plio-Pleistocene CROCODILIAN DIVERSITY USING THREE DIMENSIONAL MORPHOMETRICS OF DENTAL AND OSTEODERM REMAINS

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Modern crocodilians are a diverse group of mostly amphibious, opportunistic hunters that include twenty-three extant species. A number of extinct species have been described from Australia’s Plio-Pleistocene record based on highly fragmentary cranial remains. The aim of this study was to identify crocodilian species and species diversity using a single well collected Pliocene-aged local fauna, the Chinchilla Local Fauna. Relative to the small number of cranial remains available in these deposits, teeth and osteoderms are far more common, being more numerous and readily fossilised. Thus, they make up the largest dataset available. Our focus began with dentition and will turn to osteoderms in the near future. Differences in tooth size and shape were related to tooth location and dietary preferences, and therefore it is likely that determining the diversity of crocodilian taxa from a single local fauna (Chinchilla Local Fauna) may be possible from teeth alone. At a gross level, crocodilian teeth are similar; therefore, a combination of methods were used to help discriminate tooth shape. We undertook a quantitative analysis to help distinguish tooth shape and differentiate tooth position and species morphotype. Using three-dimensional models for analysis, the teeth were compared to each other to determine a similarity index. This provides an objective comparison that can later be integrated with other morphological traits to enhance inference of morphotype. Our results support the presence of at least two distinct morphotypes within the Chinchilla Local Fauna, most likely those previously allocated to Pallimnarchus pollens and Quinkana sp. However, jaw specimens from the site show a potential for three different crocodilian taxa occurring in the Chinchilla Local Fauna. This is further supported by detailed analysis of fine features not captured during Computed Tomography (CT) Scanning. These features include differences in denticulated surfaces, serrations and the presence or absence of fluting. All of the available crocodyloid teeth have evidence of denticulation. The remainder of the teeth are serrated with different proportions showing evidence of fluting, suggesting at least three taxa within the Chinchilla Local Fauna. Application of these results to other Plio-Pleistocene sites across Queensland indicates a similar level of species diversity where isolated dentition is known. Preliminary assessment of osteoderm morphology supports results from dentition.

Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM)

TRABECULAR BONE DENSITY IN ZOO AND WILD FELIDS

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Experimental and observational studies show that bone responds to elevated mechanical loading by increasing in mass and density. Many mammalogists who carry out ex vivo studies of extinct mammals may include samples from zoos as well as those caught in the wild and housed in museum collections. However, the effects of confinement (as is the case in zoos) on bone morphology, especially in the Local Fauna. This is further supported by morphological and dental samples occurring in the Chinchilla Local Fauna. Since little is known about the biology of these birds, we undertook a detailed investigation of their bones to deduce various aspects of their life history. This study focuses on four tibiotarsi, two tarsometatarsi and a femur of Genyornis that were recovered from the dry desert region of Australia. In addition, we expanded our previous osteohistology sample by including additional younger and adult specimens of Dromornis from the late Miocene Alcoota Local Fauna in the Northern Territory of Australia. The bone histology of Dromornis and Genyornis show that these birds experienced a cyclical pattern of growth with alternating rapid and slower rates of osteogenesis. During faster periods of growth they deposited fibrolamellar bone tissue, whilst during periods of slowed growth they formed lamellar bone tissue, which was sometimes associated with lines of arrested growth indicating pauses in osteogenesis and growth. However, we found that these birds differed in the amount of time taken to grow to maturity: Dromornis has over 10 growth cycles while Genyornis shows a maximum of 3 growth cycles. Interestingly, in Genyornis some of the lamellar deposits are wide, indicating that they grew slowly for longer periods of time. The main aridification of Australia is considered to have occurred from the late Miocene through to the Pleistocene. We postulate that the growth dynamics of the dromornithids were adapted to the particular environment in which they lived, i.e., Dromornis lived before the main aridification and therefore a k-selected lifestyle strategy would have been advantageous. However, as landscape resources became less predictable, then r-selected strategies were favoured by Genyornis. The wide bands of lamellar bone in some of the Genyornis samples may have been subject with lengthy stressful periods (drought).

Grant Information: ARC Discovery Project Grant, DP180101913
bone density in these species. Even so, dietary influences and sex differences relating to daily travel distance may also play a role. Understanding the effect of reduced loading on bone among zoo and wild specimens has implications for interpreting morphological data from extant species used as models for interpreting the mammalian fossil record.

Grant Information:
Marshall University and Peter Buck Postdoctoral Fellowship.

THE DEEP TIME ORIGIN OF AFRICAN ZEBRAS THROUGH THE EURASIAN “EQUUS STENOVAE” LINEAGE.

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The extant African zebras include Equus grevyi (Ethiopia and Kenya), Equus quagga (Ethiopia to southern Africa) and Equus zebra (Southern Africa), E. grevyi being the largest. In order to understand the evolution of the zebra clade during the Plio-Pleistocene, we have compared the cranial and postcranial features of E. grevyi with the Old World fossil Equus from North America Asia, Europe and Africa.

We carried out an analysis of cranial and postcranial elements of the following fossil species Equus simpliciden from North America, Equus sivalensis from the Indian Sub-Continent, Equus stenonis and Equus stehlinii from Italy, two yet to be named species of Equus from the paleoanthropological site of Dmanisi (Georgia), and Equus koobiforensis and Equus oldowayensis from Kenya.

Herein, we provide new hypotheses for the deep-time origin of African zebras. Remarkable similarities are seen in skulls, mandibles, upper and lower dentitions of the species cited above. Statistical analysis (Log10 ratio diagrams on the third metacarpal and third metatarsal) show similar proportions between E. simpliciden, a small species of Equus from Dmanisi and E. grevyi, suggesting a genuine deep-time origin of E. grevyi from a population derived from E. simpliciden that dispersed to Eurasia at the base of the Pleistocene, and evolved from a species of Eurasian stenonine horse. This study shows that E. simpliciden is a plausible ancestor for Old World stenonine horses, and that the extant living zebras are descendants of this lineage. These data allow us to conclude that the basic bauplan of E. grevyi was present in the Old World stenonine horses, confirming the close correlation between the extant African living zebras and the Plio-Pleistocene horses.

ABUNDANT LIZARD FISHES (AULOPIFORMES: BATHYSUARIDAE) IN AN EARLIEST PALEOGENE HORIZON IN ANTARCTICA CASTS LIGHT ON THE ORIGIN OF THE ASSEMBLAGE

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The global taxonomic richness of Cretaceous–Paleogene (K–Pg) fishes must have been profound, though only a limited amount of that original biodiversity has been described to date. Further evaluation of K–Pg fish faunas in the context of improved stratigraphic and geochronological data is critical to testing hypotheses regarding the pivotal role that the K–Pg extinction event must have played in shaping extant teleost diversity and niche occupation. During 2016, an Antarctic Peninsula Paleontology Project expedition to K–Pg deposits of the James Ross Basin (JRB) of the Antarctic Peninsula recovered dozens of partial to nearly complete fish skeletons from a stratum immediately overlying the K–Pg boundary on Seymour Island. Assigned to the uppermost López de Bertodano Formation, fishes in this horizon have previously been proposed to be representative of a mass death assemblage that was generated as a direct consequence of the K–Pg extinction event. Exceptionally-preserved taphocoenoses such as this ‘Seymour Fish Horizon’ (SFH) are often generated under unusual environmental or climatic circumstances; moreover, models predict that such perturbations would have been amplified in high-latitude Antarctic K–Pg paleoenvironments. Given the age of the SFH, at least two potentially viable alternatives exist regarding its origin: the assemblage is the result of (1) a catastrophic mass mortality event, possibly related to more global events that occurred at the K–Pg boundary (e.g., the Chicxulub bolide impact); or (2) a more attritional accumulation of fish carcasses amassed through reworking and/or time-averaging of
individuals that died or were killed asynchronously. Fossils in the SFH have historically been described only as "fish debris," without taxonomic specificity. Here we report the first articulated fossils of benthic litorid fishes, similar to the extant Bathysaurus, to be recovered from the SFH and the JRB as a whole. Litorid fishes are estimated to have appeared during the Early Cretaceous, and Bathysaurus itself is thought to have originated in the Late Cretaceous. Extant litorid fishes are abundant at abyssal depths at temperate and tropical latitudes, mirroring their abundance in the SFH. The Antarctic fossils share with selected extant litorid fishes a medial pelvic girdle process that is joined by cartilage (i.e., unfused) and a brush-like postdorsal outgrowth of the first neural arch. The recognition of fossils in the SFH as those of deep-sea taxa sheds new light on the genesis of this singular assemblage.

Grant Information:
National Science Foundation, ANT_118473

Technical Session VII (Thursday, October 10, 2019, 9:45 AM)

**A NEW BASAL CROCDYLOVROMorph FROM THE NUGGET SANDSTONE OF UTAH – THE MOST COMPLETELY KNOWN “SPHENOSUCHIAN”**

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"Sphenosuchians" (non-crocodiliform crocodylomorphs) are critical to understanding the origins of many features that are apomorphic for living crocodylans. All currently known specimens are incomplete, several species are known only from the holotype specimen, and ontogenetic changes are not yet documented. We report here a new "sphenosuchian" known from multiple nearly complete skeletons, from the Late Triassic Nugget Sandstone of NE Utah. The specimens were preserved in interdunal lacustrine sandstones along with remains of theropods, pterosaurs, drepanosauroids, sphenodontians, and procolophonids. A minimum number of 87 individuals are known based on femora, and 35 specimens are articulated to some degree, including 14 articulated, relatively complete skulls. The specimens are relatively small, with skulls ranging from 23 mm to 42 mm and femora from 14 to 59 mm. Despite the range of sizes morphological differences are subtle. The new taxon is superficially similar to Terrestriscius, but is that likely due to their small size and possibly to young ontogenetic stages of known specimens. The craniaquadrate passage is open, unlike in Macelognathus, Almadosaurus, and crocodyliforms. A heavily fenestrated quadrate is shared with these latter taxa but may reflect an early ontogenetic stage, as in extant crocodylans. Like Almadosaurus and crocodyliforms it lacks basipterygoid processes, and instead the basiphenoid has an unusual ventrolateral ridge along its lateral edge. The scapula is relatively narrow anteroposteriorly, unlike the broader element in Juncugarsus and crocodyliforms, and the coracoid has a posteroventral process but lacks the elongate, cylindrical projection of Diplotaxiscus and Juncugarsus. The pubis lacks an obturator foramen, unlike Terrestriscius, and the femoral head is not as distinctly inturned as in Kayentasaurus, Almadosaurus and Hallopus.

A phylogenetic analysis based on firsthand examination of most sphenosuchians and CT scans of the skull of the Nugget form and several other sphenosuchians places the new taxon with basal "sphenosuchians," indicating that the lack of basipterygoid process and the highly fenestrated quadrate, if present in adults, evolved homoplasically in the new form and in crocodyliforms and some "sphenosuchians." The limited amount of pneumaticity, other than in the quadrate, and more weakly developed femoral head are consistent with other Triassic "sphenosuchians" and unlike most Jurassic taxa.

Grant Information:
NSF EAR 1636753 to JMC

Symposium: From Molecules to Macroevolution (Wednesday, October 9, 2019, 9:45 AM)

**METABOLIC PHYSIOLOGY EXPLAINS MACROEVOLUTIONARY TRENDS IN THE MELANIC COLOUR SYSTEM ACROSS AMNIVORES**

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Metabolism links organisms to their environment through its effects on thermoregulation, ecology and energetics. Genes involved in metabolic processes have described pleiotropic effects on some melanin colour traits. Understanding links between physiology and melanin colour is critical for understanding the role of, and potential constraints on, colour production. Despite considerable variation in metabolic rates and presumed ancestral melanin coloration in vertebrates, few studies have looked at a potential relationship between these two systems in a comparative framework. Here, we test the hypothesis that changes in melanosome shape in integumentary structures track metabolic rate variation across amniotes. Using multivariate comparative analyses and incorporating both extant and fossil taxa, we find significantly faster rates of melanosome shape evolution in taxa with high metabolic rates, as well as both colour- and clade-specific differences in the relationship between metabolic rate and melanosome shape. Phylogenetic tests recover an expansion in melanosome morphospace in maniraptoran dinosaurs, as well as rate shifts within birds (in songbirds) and mammals. These findings indicate another core phenotype influenced by metabolic changes in vertebrates. They also provide a framework for testing clade-specific gene expression patterns in the melanocortin system and may improve colour reconstructions in extinct taxa.

Grant Information:
NSF EAR 1251922 and NSF EAR 1355292 to J.A.C.; Integrative Research Center Postdoctoral Fellowship, FMNH to C.E.

Technical Session XVIII (Saturday, October 12, 2019, 3:00 PM)

**EARLIEST PUERCAN 1 (PUI) FAUNAS FROM MONTANA WITH INSIGHTS ON MAMMALIAN TAXONOMIC AND ECOLOGICAL RECOVERY AFTER THE K-PG MASS EXTINCTION EVENT.**

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Biotic recovery following ecological disaster is often investigated using taxonomic proxies (e.g., relative abundances and richness). This approach neglects other proxies of ecological recovery (e.g., body size and diet) that can be decoupled from taxonomic proxies. The relative dynamics of these proxies offer insight into models of recovery that are relevant to modern systems. The Cretaceous-Paleogene (K-Pg) mass extinction marked the demise of non-avian dinosaurs and the rise of mammalian-dominated terrestrial ecosystems. The quantity and quality of palaeontological data makes this event a superb model to investigate both the taxonomic and ecological aspects of biotic recovery. Here, we build on past work tracking changes in taxonomic composition and diversity by tracking body size and dietary habits within earliest Paleogene mammalian local faunas from Garfield County, Montana, U.S.A. We recovered mostly isolated mammal teeth via surface collection and screenwashing of the Herpijunk, Morales 1, and Carrie Paddlet localities. These localities form a time sequence allowing high-resolution insights into mammalian faunal recovery during the first ~80 Ka after the K-Pg. Body-mass estimates were made using taxon-specific formule and were averaged for each locality. Average body-mass across sampled localities did not change and remained small (~5kg). Each taxon was assigned to a dietary category (faunivore, animal-dominated omnivore, plant-dominated omnivore and herbivore) according to our observations and the published literature. Animal-dominated omnivores have the highest abundance around 86% on average followed by faunivores. Faunivory, plant-dominated omnivory and herbivory each represent less than 10% of total abundance in each locality. Overall dietary category abundances were stable from the oldest to youngest localities. Previous work investigating these localities support a mammalian recovery model in which older Pu1 localities have high relative abundances of disaster taxa (Mesodon spp.) and low richness. Our results indicate stable average body-mass and dietary category abundances in the three localities. There is little evidence demonstrating a decoupling of taxonomic and ecological recovery, which may be a result of the limited temporal range of our study system. Future work will extend the temporal range and resolution of the analysis to continue to investigate the dynamics of biotic recovery.
Late Miocene cooling (LMC, 7.0-5.4 Ma) marks an interval of significant, rapid temperature decline (up to 6°C) recorded in marine sediments and associated with the establishment of a near-modern climate state. In terrestrial settings, this event correlates with significant global aridification and expansion of C4-dominated grasslands, with a corresponding increase in the proportion of hypsodont (high crowned) and hypselodont (ever-growing dentition) taxa within mammalian faunas. While contemporaneous terrestrial records from South America suggest a similar pattern, their interpretation is complicated by regional tectonism associated with ongoing uplift of the Andes. Here, we sought to re-evaluate these records by selecting basins from areas where present-day elevations had been established by the Late Miocene, thereby removing tectonic effects, and examining changes in carbon (δ13C) and oxygen (δ18O) isotopic compositions of pedogenic carbonates and fossil tooth enamel solely within the context of climate change associated with the LMC. These records were then compared with general circulation global climate model simulations to identify the most likely mechanism responsible for changes observed within these terrestrial ecosystems.

Published δ13C and δ18O records of pedogenic carbonate and fossil enamel values were compiled from 14 localities in Bolivia and Argentina spanning 15°S to 35°S. Pedogenic carbonate δ13C and δ18O values, in general, rose across the LMC, most robustly occurring in the subtrivets (25 to 30°S), suggesting aridification and expansion of C4 grasses. Mammalian faunas from the subtrivets showed the strongest response across the LMC with an increase in C4 grass consumption as evident from elevated enamel δ13C values and an increase in abundance of hypsodont and hypselodont taxa. The early acquisition of high-crowned teeth by these taxa would have primed them to take advantage of the expansion of open, arid habitats during the LMC. Climate model simulations, which were run under different magnitudes of LMC steepening of equator-to-pole temperature gradients and CO2 decline, suggest these environmental changes could be attributed to strengthened Hadley circulation, which would enhance moisture divergence away from the subtropics and towards the Intertropical Convergence Zone.

Grant Information:
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OREODONT ADAPTATION AND EXTINCTION IN THE CENTRAL HIGH PLAINS, MIOCENE NORTH AMERICA

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Oreodonts were not only abundant during the middle Cenozoic, but they were also widespread and diverse. In the Oligocene and Miocene, oreodonts diversified while grasslands expanded and open savannas replaced closed forests, one of the greatest ecological transformations in the Cenozoic. Grassland expansion increased selection pressure for grazing morphologies as grasses became more abundant than leafy browse and the distance between patchy feeding resources increased. The current paradigm attributes oreodont extinction to a lack of adaptive change to grass dominated, open environments. Collections from four museums were used to assess adaptive change in oreodonts between 37 Ma and 9 Ma in the Central High Plains. A series of 73 undeformed skull attributes and 34 postcranial attributes were measured on 237 individuals. To better constrain cranial ecrometricals, a new set of cranial long bones were adopted to create a three-dimensional mesh of the feeding characters of the skulls. This allowed for comparison of cranial loci orientation and position, increasing the total number of traits, while avoiding the time and costs associated with scanning technologies. Ecrometrical analysis of the skull attributes resolves four distinct groups through time. The first three groups progress through origination, radiation, and specialization with a directional shift from browsing to grazing. The final survival group shifts back toward a mixed feeding type of medium size. Analysis of limb attributes indicate a more subtle trend through time toward grazing and follows a similar pattern of origination, radiation, specialization, and survival. These results challenge the existing paradigm that oreodonts did not adapt to their changing environment with additional implications for current conceptions in oreodont phylogenetics. Grasslands expanded at different rates in the central High Plains and northwestern United States so future research will compare oreodont ecrometries and changing community structures in these areas.

Grant Information:
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RETHINKING THE ASSEMBLY OF CHIMAEROID FISHES

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Chimaeroids, now represented by a mere fifty living species, constitute one of the four primary divisions of extant gnathostomes. Chimaeroid cranial morphology combines the classic lungfish character-suite of choanae, toothplates, fused palate, and reduced hyomandibula, with further specializations including (but not limited to) a deep snout, ethmoid canal, and huge orbits with an elevated skull roof. Although firmly rooted among chondrichthians, the challenge of relating the earliest chimaeroids to other kinds of fossil shark continues to be problematic because of the paucity of likely transitional forms. However, recently published data on synomorph crania and new insights into the structure of Carboniferous holoccephalans enable re-consideration of the origin of the chimaeroid cranial morphotype, and re-evaluation of long-established transformation scenarios debated by Patterson, De Beer and Moy-Thomas. In summary, our analysis favors the following sequence of character evolution: initially, orbit enlargement, the near-union of left and right otic labyrinth spaces across roof of the hindbrain, and enclosure of the pre-oral
ophthalmic nerve. These changes preceded the essential structural and functional step of palatal fusion to the braincase. In agreement with Prifti, the ethmoid canal has never been part of the cranial cavity, sensu stricto. Moreover, the precerebral fontanelle persists (in phylogeny) while orbitonasal the ethmoid canal has never been part of the cranial cavity, sensu stricto. Notably, chimaeroid tooth-plate origin involved spatial changes, the lateral fusion and/or displacement of tooth series, and heterodont and bradyodont trends in tooth generation, implying changes to the distribution and activity of dental laminae through ontogeny and phylogeny. It appears that such changes occurred mostly before the end-Devonian extinction, thereby preconfiguring holoccephalan survivors to exploit the exceptional, crinoid-dominated continental shelf environments of the Lower Mississippian, and launching the singular, extraordinary vertebrate clade.

Grant Information:
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Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)

STABILITY OF DENTAL MESOWEAR SCORES THROUGHOUT THE LATE PLEISTOCENE IN LARGE Ungulates FROM RANCHO LA BREA

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The Rancho La Brea locality (California, U.S.A.) is world famous for its asphalt deposits that trapped late Pleistocene mega fauna over the last 50,000 years. This wealth of paleontological data allows for detailed investigation into paleoecological changes through the last glacial maximum into the Holocene. Previous studies have inferred dietary changes in herbivorous taxa at Rancho La Brea using dental mesowear in conjunction with microwear and enamel stable isotopes, focusing on two deposits: Pit 61/67 at ~11.5 Ka and Pit 77 at ~35 Ka. Here, we examined the mesowear of additional specimens of Bison antiquus, Equus occidentalis, and Camelops hesternus from five pits spanning the latest Pleistocene (~12–40 Ka): pits 61/67, 3, 13, 91, and 77. Five observers scored mesowear for each specimen and the mesowear numerical scores (MNS) were compared between pits and taxa, as well as the taxon examined did not differ through time (i.e., between pits, all p-values >0.11). Additionally, E. occidentalis consistently had higher MNS values (mean of 3.8) than both B. antiquus and C. hesternus and were indistinguishable from modern grazers (p=0.19). B. antiquus and C. hesternus MNS values (mean of 1.6 and 1.5, respectively) were consistent with modern browsers (p=0.03 and 0.17, respectively). The values for B. antiquus (all pits combined) differ significantly from those for the modern grazer B. bison (p<0.001). The stability of mesowear signals between pits is in contrast to previous studies that found changes in diet across the late Pleistocene using microwear and stable enamel isotope dietary proxies. These differences in dietary interpretation may be due to the different signals each proxy represents. Dental mesowear signals reflect abrasives in or on food consumed while dental microwear textures record the textural attributes of food consumed, both representing different amounts of time. Previous studies using age structure and serial enamel isotopes have suggested that E. occidentalis and B. antiquus migrated into Rancho La Brea yearly, so dental microwear may signal the specific diet consumed at Rancho La Brea while dental mesowear may represent feeding behavior at and beyond Rancho La Brea.

Grant Information:
National Science Foundation #1751187

Technical Session IV (Wednesday, October 9, 2019, 3:15 PM)

SAMPLE SIZE ARTIFACTS IN PALEONTOLOGICAL ANALYSES OF ONTONGENETIC SEQUENCES

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Establishment of ontogenetic sequences for fossil species is generally compromised by small sample sizes. Although this does not diminish the importance of ontogenetic sequence as a tool for estimating the maturity of individuals (often a prerequisite for interpreting whether a specimen represents a different taxon, or simply a different ontogenetic state from a reference specimen), it does mean that certain precautions should be observed when comparing ontogenetic sequences between taxa. Here a hypervolume heuristic is employed to explore the ramifications of sampling bias. In general, ontogenetic sequence resolution within a taxon or population depends on the number of specimens relative to the number of included events. Complete sequence resolution (i.e., every event’s position resolved relative to every other event) minimally requires as many sampled individuals as ontogenetic events. In practical terms, one needs to include many more individuals than events because it is unlikely that all sampled individuals represent a unique ontogenetic condition. Furthermore, ontogenetic event-order can be variable, requiring large samples to establish the frequency of variant sequences. The negative effects of inadequate sampling are preventable, and include poor resolution and underestimation of sequence variation. Unfortunately, many studies assume that lack of resolution indicates event synchrony, which leads to a false equivalence of sequence position in comparative analyses. Underestimating sequence variation results in a false assertion of fixed sequence order for events, which also affects comparative analysis.

The hypervolume heuristic illustrates the consequences of inadequate sampling, and proffers a framework for sequence comparison. This framework includes a predictable distribution of sequences differing from a reference sequence, and the likelihood for erroneous interpretations when resolution is not adequate. The hypervolume can inform the suitability of sequence comparison between taxa, and presents a rationale for targeted sampling to address sampling biases. In general, while attempts to establish ontogenetic sequences are encouraged, even with limited samples, it is imperative to evaluate sampling effects – particularly with comparative analyses. Analysis of topological differences in ontogenetic hypervolume-space is considered the most promising avenue for interpreting ontogenetic sequence evolution while accounting for sequence sampling artifacts.

Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM)

TATE GEOLOGICAL MUSEUM - A VALUABLE RESOURCE FOR VERTEBRATE PALEONTOLOGICAL RESEARCH AS WELL AS ENHANCING LIBERAL ARTS EDUCATION.

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The Tate Geological Museum (TGM) of Casper College, Wyoming will be celebrating its 40th anniversary in the 2019-2020 academic year. The TGM was built as a gift to Casper College by the Tate Family in Casper. Originally a mineralogical museum, the facility has developed into the second most important collection of vertebrate fossils from Wyoming in Wyoming. Like all museums, it had its share of good fortune and challenging, unstable funding sources and staffing issues. However, in the late 1990’s, Casper College recognized the value of having a natural history museum on campus for student access and as a community resource. The addition of full-time staff has allowed the museum to expand into what it is now in the plans. The facility has become a place for internships, training in collections management, and host to an annual conference. For the past dozen years or so, the museum has been recognized by the Bureau of Land Management as a federal fossil repository and houses many important specimens. Along with the generous donations from community members and landowners, the museum is actively collecting from new and older sites and now has an extensive collection of vertebrate taxa from Wyoming, available to researchers and to visitors alike. Recent collections include up to 120 unidentified mammal teeth and jaws from a single ant hill associated with Cretaceous sediments, nearly complete carpac and plastron from the Morrison Formation, a partially articulated Tyrannosaurus rex, and access to one of the most numerous pterosaur tracks and trackways in the world. The TGM invites researchers to consider contacting the museum to see what the museum can do to help with their next project.

Regular Poster Session III (Friday, October 11, 2019, 4:15 - 6:15 PM)

CHALICOTHERES OF PAKISTAN: PIECING TOGETHER THE BIOGEOGRAPHIC PUZZLES OF A RARE PERISSODACTYL GROUP IN THE NEOGEOGRAPHY OF SOUTHERN ASIA

COOMBS, Margery C., University of Massachusetts Amherst, Amherst, MA, United States of America; COTTE, Susan, University of Calgary, Calgary, AB, Canada
Chalicotheres (Perissodactyla) have a fragmentary and sporadic fossil record for the Indus-Pakistan subcontinent in the Oligocene. Occurrences of these unusual clawed herbivores in Pakistan contribute useful windows for understanding regional environments and biogeographic relationships during the Neogene. Chalicotheriids belonging to both the subfamilies Schizotheriinae and Chalicotheriinae appear near the Oligocene-Miocene boundary in Bugti Hills and Zinda Pir in Pakistan. Best known from teeth but otherwise mostly enigmatic, *Phyllitolion naricus* was among the earliest schizotheriines to fuse proximal and middle phalanges of the second digit of the manus. It is thus pivotal for understanding the spread of Miocene Schizotheriinae across Eurasia and into North America. "Chalicotherium" *pilgrimii*, poorly known but recognizable from distinctive postcranial elements, helps elucidate the route via which Chalicotheriinae reached East Africa in the early Miocene. But, like earlier representatives, retain characters (such as a relatively short jaw symphysis) found in such basal ancodont chalicotherines as *Anisodon grande* (Europe). *A. salinus* also resembles *Anisodon yuamosensis* from Myanmar and southeastern China; the distributions of *A. salinus* and *A. yuamosensis* suggest a geographic continuum of conservative ancodont chalicotherines living in subtropical forested environments south and east of the Himalayas into the late Miocene. Schizotheriinae are generally not found in the Middle Siwaliks, though a single tautalizing lower molar from Locality Y56 (~10.1 Ma) is identified as cf. *Ancylotherium* sp., a genus otherwise typical of the Pekinian Biome of northern China, Afghanistan, Iran, and Turkey, extending into southeastern Europe and Africa. 3) *Nestoritherium vivianeae* from Upper Siwalik deposits of Plio-Pleistocene age represents the final occurrence of the Chalicotheriinae in Pakistan. Nestoritherium is a derived ancodont best known from northern China. Its occurrence in Pakistan is more likely the result of immigration than evolution in situ from earlier *Anisodon salinus*.

Grant Information:
Funding provided by the University of Calgary and the Natural Sciences and Engineering Research Council of Canada.

**Regular Poster Session III (Friday, October 11, 2019, 4:15 - 6:15 PM)**

**A MORPHOMETRIC ANALYSIS OF THE CROCODYLLIAN SKULL TABLE: TRACKING ALLOMETRY AND PREDICTING ECOLOGY**

COSSETTE, Adam, University of Iowa, Iowa City, IA, United States of America; GRASS, Andrew, AT Still University, Mesa, AZ, United States of America

The dorsal portion of the crocodilian skull, posterior to the orbits, is referred to as the skull table. To explore shape variability an analysis using geometric morphometric methods is conducted with the inclusion of both extinct and fossil taxa. In addition, comparisons of allometric change within taxa are examined - crocodylian body mass greatly increases during development and is associated with significant change in cranial morphology.

This project uses 240 specimens from 58 species. Four separate analyses are performed: two outline analyses, an analysis exploring the allometric trajectories of skull table outlines, and an analysis of the allometric trajectories of skull table outlines with additional landmarks covering the morphology of the supratemporal fenestrae. Each species is assigned categorical variables depending on its phylogenetic relationships and snout length. A permutation procedure is used to test for instances of convergence, parallelism, and divergence among the allometric trajectories. Results demonstrate overlap in morphospace between Alligatoroidea and Crocodyloidea whereas *Boreosuchus* and *Gavialoidea* are more restricted. The overlap between Alligatoroidea and Crocodyloidea may be the product of a more recent common ancestor and/or shared snout shape categories. With the inclusion of landmarks representing the supratemporal fenestrae, Gavialoidea is broadly separated from the other groups as a result of having proportionally massive fenestrae. It has been hypothesized that the size of the supratemporal fenestrae are influenced by snout length, with longer snouts corresponding to larger fenestrae. Although species of the crocodyloids *Tomistoma* and *Eucrocodylus* approach or exceed the length of the snout in gavialoids their supratemporal fenestrae are proportionally smaller - this suggests a phylogenetic constraint in crocodyloids regardless of snout length. Among the allometric trajectories adults of the smallest extant taxa plot alongside the juveniles of larger taxa - this may indicate that paedogenesis is present in the skull table outline of these taxa whose diminutive size may have been achieved via maintenance of juvenile morphologies through ontogeny.

The biological implications of skull table shape, other than raising the eyes and ears above the waterline, are largely unknown. Shape likely plays a role in hydrodynamics, species recognition, and biomechanical adaptations. This study tests the hypothesis that the quantification of skull table shape in Crocodylia.

**Technical Session I (Wednesday, October 9, 2019, 9:30 AM)**

**DAUNTING DENTITIONS: TUSKS AND TEETH IN THREE OLIGOCENE DOLPHINS FROM NEW ZEALAND**

COSTE, Ambre M., University of Otago, Dunedin, New Zealand; FORDYCE, Robert E., University of Otago, Dunedin, New Zealand; LOCH, Carolina, University of Otago, Dunedin, New Zealand

New Zealand fossil dolphins include 3 named species with elongate procumbent teeth (*Waipatia maurevichena*, *Otekaekea marplei* and *Otekaekea hauia*; *Waipatia*; *Platanistoidea*). All the teeth are isolated from their alveoli, with uncertain original positions. Three unnamed new species (based on specimens OU 22397, OU 22126 and OU 22662) now preserve tusks in situ in 22397 and 22126. These longirostral, tusked dolphins are from marine mid-shelf strata, the Kokoamu Greensand and Otekaike Limestone (Chattian, ~26 Ma, to possibly basal Aquitanian, ~23 Ma), of the Waitaki region. Phylogenetic analyses place these in the Platanistoidea, though relationships are unstable.

In all three new species, the maxillary teeth are polydont: markedly heterodont. The overlap between *Alligatoroida* and *Crocodyloidea* may be the product of near-homodont in OU 22262 (which lacks the rostrum); less differentiated in OU 22397; and near-homodont in OU 22126. The latter 2 have well-preserved elongate, attenuate, and dorsoventrally flattened rostra; both rostra are more than twice as wide as deep at the level of the canine. The nasorostral angle is almost equal in elongate premaxillae which form the anterior 23% of the rostra in both specimens. Only OU 22397 has a relatively complete mandible, which shows alveoli for similarly long procumbent tusks and a long unfused symphysis along ~38% of its length.

Where the teeth are in place or alveoli observable, II is parasagittal and horizontal, with a symmetrical crown and a straight axis from crown tip to root tip. I2 and I3 are less symmetrical, splayed out laterally. The canine is missing; the cheek teeth push back to be increasingly added in elongate premaxillae which become more differentiated posteriorly. The posterior cheek teeth in OU 22662 and OU 22397 have reduced accessory denticles which are nearly imperceptible in OU 22126.

The placement of the tusks in the rostra indicates differences in tooth eruption amongst the 3 specimens. None of the teeth show evidence of extensive abrasive wear or attrition, other than right I2 of specimen OU 22397 which appears to have been broken and subsequently worn throughout lifetime at an angle of about 20° to the tooth’s long axis.

The generally-pristine condition of the tusks suggests delicate occlusion or contact with exogenous material. How could these unusual tusks have been used? The dorsoventrally compressed rostrum might allow more rapid lateral movements. Uses could include slashing for feeding (as in *Pristis*; sawfish) or hunting infralabial bony prey, for defence or agonistic behaviour, or display.

Grant Information:
University of Otago Postgraduate Scholarships
National Geographic Society Grants 4341-90 & 5381-94

**Technical Session VI (Thursday, October 10, 2019, 11:30 AM)**

**AN USUAL FOSSIL HOMINOID ASSEMBLAGE FROM TINDERET, KENYA**

COTE, Susanne, University of Calgary, Calgary, AB, Canada; MCNULTY, Kieran, University of Minnesota, Minneapolis, MN, United States of America; KELLEY, Jay, Arizona State University, Tempe, AZ, United States of America

Early Miocene sediments in both Kenya and Uganda sample abundant and diverse remains of early fossil hominoids (apes). One particularly important area is Tinderet in Western Kenya, which includes more than 50 separate fossil localities. Despite their relatively close temporal and geographic proximity, these localities contain different ape species – some taxa are restricted to just a handful of localities (e.g., *Rangwapithecus gordonii*), while others (e.g., *Proconsul major*) appear to be very widespread. Locality “Koru 16” has been known to paleontologists for many decades, and several fossil ape specimens have been described in the literature. Previously, material from Koru 16 has been attributed to *Proconsul major*, *Proconsul africans*, and *Limnopithecus legeti*.

We recovered additional ape fossils during geological and paleontological fieldwork at Koru 16. These new specimens make it clear that Koru 16 samples a new taxon of large-bodied ape that is similar in size to *P. major*, but morphologically distinct. A single lower molar, likely m2, has well-developed shearing crests, is mesiodistally elongate, and lacks a clear

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and a burrin tip. From these morphological features, the lower molar and possess bulbous roots, and lack longitudinal fluting and striations on the root. Our comprehensive review of all hominoid fossils from Koru 16 suggests that nyanzapithecine.

A TALE OF TWO MICE: POGONOMYS AND LEGGADINA (RODENTIA: MURINAE) FROM PLEISTOCENE CAVE DEPOSITS AT MT ETNA, EASTERN QUEENSLAND, AUSTRALIA.

Grant Information:

Cramb, Jonathan, Queensland Museum, South Brisbane, Australia; Hocknull, Scott, Queensland Museum, Brisbane, Australia; Price, Gilbert, The University of Queensland, St Lucia, Australia

Middle Pleistocene cave deposits at Mt Etna (eastern Queensland, Australia (AUS)) record the regional extinction of rainforest and its replacement by xeric habitat. The rainforest assemblage from Mt Etna is similar to older Oligo-Pliocene rainforest faunas by possessing extant lineages that are rainforest obligate. The fauna records the nearest-time fossils of the very rainforest species providing a Quaternary baseline for species diversity within AUS rainforests. An intriguing feature of the Mt Etna rainforest fauna is that it includes taxa with extant members that do not currently inhabit rainforest. This feature has also been observed among marsupials, particularly dasyurids, permelids and pseudochaerids. The origin of these 'atypical' assemblages and the question of how (and when) rainforest faunas became 'modern' are some of the foci of our ongoing research into the Mt Etna Quaternary faunas.

The late Triassic to early Jurassic was a time of high terrestrial diversity and disparity in archosaurian reptiles, initially with the pseudosuchians and then dinosaurs. However, the modern diversity of archosaurs is restricted to crocodilians and birds. Here we investigated the functional disparity of archosaur hindlimbs, widely seen as remarkable, using biomechanics. Skeletal models of fossil and extant species of pseudosuchians (Batrachotomus, Pogonomys and Nile crocodile) and dinosauromorphs (Marasuchus, Lesothosaurus, Coelophysis, Massasaurus, and elegant-crested tinamou) were digitized, and muscles added to these models in musculoskeletal modelling software. We then calculated ranges of motions (ROM) and normalized muscle moment arms of the hip, knee, and ankle. Pseudosuchian taxa generally had the greatest ROM in hip flexion/extension, whilst dinosauromorphs had the greatest ankle extension (due to the absence of the enlarged calcaneal tuber). Across the other joints, ROM was similar between the taxa. Muscle moment arms varied widely depending on the method of size-normalization. When the cube root of body mass was used, smaller taxa had larger moment arms around most joint axes. When scaled against femoral length, Massasaurus had the largest hip flexion/extension moment arms for the M. caudofemoralis longus, but the smallest for M. flexor tibialis externus. Extinct pseudosuchians had some of the largest M. gastrocnemius moment arms, as expected from the calcaneal tuber; and comparable to birds. Hence there is a tradeoff in ankle mobility and leverage in archosaurs. The fossil taxa and crocodile retained ancestral hip abduction/adduction moment arms, contrasting to the patterns in birds. By using 3D musculoskeletal models we can explicitly quantify functional disparity and evolution of archosaurian hindlimb function, and we discovered important lessons about tradeoffs between different methods of normalizing muscle moment arms.

The utility of periosteal aging to assess the maturity of isolated theropod cranial and femoral elements.

Cunningham, Patrick, Salt Lake City, UT, United States of America; Loewen, Mark A., University of Utah, Salt Lake City, UT, United States of America; Sertich, Joseph, Denver Museum of Nature & Science, Denver, CO, United States of America

Ontogenetic changes in the periskeletal surface textures of appendicular elements have previously been recognized in extinct taxa as well as in extant birds. Typically, a linear, striated surface texture in fast growing juvenile bones progresses to a clotted, interwoven texture in mature adults. Cranial elements and femora of Allosaurus fragilis from the Jurassic Cleveland L. Dinosaur Quarry of North America and Masiakasaurus knopleri from the Maaschrichtian Maevanaro Formation of Madagascar were photographed macroscopically to document bone surface texture. The images were categorized into three groups based on the bone surface texture (striated, intermediate, clotted/interwoven), independent of absolute size. These categories were then compared to linear measurements and to previously reconstructed growth curves based on histologic evidence. Specimens of Allosaurus are ideal for analyzing periosteal aging because they provide a vast range of well-preserved elements across multiple sizes. Femoral bone surface textures closely track absolute ages in specimens that have been histologically aged. We examined cranial periskeletal surface textures in disarticulated elements of Allosaurus and found similar decreases in linear striated surface textures with increases in size in both the maxilla and dentary. We examined femoral and cranial elements of the neosaurid Masiakasaurus to determine periskeletal surface textures in a more basally-branching, small-bodied theropod. We found woven adult surface textures in most large limb bones, and intermediate texture in smaller individuals. All large cranial materials including the maxilla and dentary show adult texture, while a smaller dentary exhibits intermediate texture. When combined with published reports of bone surface maturity in ceratopsians, tyrannosaurs, and ornithopods, bone surfaces can give an accurate first approximation of skeletal maturity even in the case of an individual long bone or isolated cranial element. Bone surface texture has a place in assessing maturity and can be used as a reliable proxy for maturity when making taxonomic assessments.
A NEW MEGALOSAURID THEROPOD FROM THE MIDDLE JURASSIC XINTIANGOU FORMATION OF CHONGQING, PEOPLE'S REPUBLIC OF CHINA AND ITS IMPLICATION FOR EARLY TETANURAN EVOLUTION

DAI, Hui, Chongqing No. 208 Hydrogeological and Engineering Geological Team, Chongqing, China; XU, Xing, Institute of Vertebrate Paleontology & Paleoanthropology, Beijing, China

Megalosaurus represent one of the first radiations of large-bodied theropods, and are known from the Middle–Late Jurassic of Europe and North America. Here we report a new theropod, Yunyangosaurus puantensis gen. et sp. nov., based on a fragmentary specimen recovered from the Middle Jurassic Xintiangu Formation of Chongqing, southwestern China. It shares several features uniquely with some megalosaurids (the clade of megalosaurus + spinosaurids + piatnitzkysaurids), such as prominent rims around the anterior articular surfaces of cervical centra. Megalosaurus affinities are supported by a morphometric analysis. Nevertheless, it also shows several features that are rare or absent among derived tetanuran theropods, including the presence of a posterior pneumatic foramen (absent in most tetanurans, but variably present in megalosaurids), prominent spinocephopseal laminae (also present in non-tetanurans and metriacanthosaurus alliaceous), and flat anterior articular surfaces of the cervical centra (also present in piatnitzkysaurids and some early-diverging tetanurans) that are generally absent in most other tetanurans. Yunyangosaurus therefore presents a combination of derived and apparently primitive character states with implications for our understanding of the character evolution among early tetanuran theropods.

Grant Information:
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Preparators’ Session (Thursday, October 10, 2019, 3:00 PM)
MOVING AND UPDATING THE MOUNTED TYRANNOSAURUS REX, “SUE”

DALLMAN, Garth, Research Casting International, Trenton, ON, Canada; SIMPSON, William F., The Field Museum, Chicago, IL, United States of America; GEIGER, Lisa, The Field Museum, Chicago, IL, United States of America

FMNH PR2081, or “SUE” is undoubtedly the most well-known Tyrannosaurus rex skeleton in the world. After being “temporarily” mounted in Field Museum’s large main hall for 18 years, the museum wanted to finally finalize it into its own exhibit as part of the array of halls that make up the Evolving Planet Exhibition on the second floor. As the most complete example of T. rex, SUE is both an important scientific specimen, but has also become an icon for both Field Museum and Chicago. The decision to move the specimen presented an opportunity to update the mount and include elements not mounted previously.

Moving any large real fossil skeleton is a challenge but moving one of great intrinsic, academic and monetary value made the project challenging. The job included dismantling the existing mount, executing a condition report on all the bones, and carefully packaging everything for the move upstairs to the new exhibit hall which served as the workshop for the re-assembly. Some changes were made to the mount, and armatures for new elements were added. The museum requested that this whole process be done in public view, further increasing the complexity of the project.

The majority of the mount was reused, but some portions were altered to create a more life-like pose. The cervical ribs were mounted more parallel to the vertebral column, the dorsal ribs were swept back a bit, making the skeleton less barrel-chested, and the right knee was extended giving the animal a less crouched pose. The real, but pathologic, furcula replaced the previous reconstructed element which represented an educated guess at the time the specimen was first mounted. The scapulocoracoids were brought closer to the midline to articulate with the real furcula, which resulted in the pectoral girdle and forelimbs being moved anteriorly and ventrally to fit the ribcage. Finally, a new armature was created for the gastralia adding the largely complete gastric basket to the mount for the first time.

Changing the pose of a skeleton is like pulling a thread. One modification has rippled effect invariably affecting other areas of the skeleton. The movement of such a large, real skeleton required careful coordination between the mounting crew, exhibit registrars and collections management to preserve this unique specimen. The alterations to the mount of “Sue” were done under the direction of the exhibit curators led by Peter Makovicky, and has resulted one of the most scientifically accurate Tyrannosaurus rex skeletons on display today.

ISOTOPE DIET ( &Delta;13C) IN A MATHEMATICAL MIXING MODEL: REFERENCE THE FOOD RESOURCES THAT EXTINCT LARGE HERBIVORES ATE

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This communication aims at refining palaeodietary reconstructions for herbivorous extinct large mammal taxa through a mathematical mixing model using carbon isotopic values, to infer the proportions of three types of food resources, i.e., leaves, fruits and C4 grass. Different tissues of C3 plants show different values of enrichment, for example, leaves in C3 plants are depleted in 13C about -1.0 ‰ compared to other non-photosynthetic tissues like fruits (on average 1.5±0.07 ‰ ) and roots (on average 1.1±0.09 ‰). In contrast, C4 plants tend to show no 13C-enrichment in tissues such as fruits and roots compared to leaves. To distinguish different plant food resources, we suggest to apply carbon isotopic ratios (summing proportions of leaves and fruits) and, values attributed to fruits and leaves (pie = 0.06±0.10), which have a diet composed mainly of fruits (on average 92 ±0.50 ‰), consumption of leaves and fruits were varied (from 7.5% to 100 %), and values attributed to fruits and leaves (pie = 0.07±0.09), which have a diet composed mainly of leaves and C4 grass in two equations. The use of carbon in one isotopic mixing model considering three resources allow us to refine the type of C3 plants (leaves and fruits) consumed by herbivores. The proportions of C3 (summing proportions of leaves and fruits) and C4 plants in this model present similar values if we compare the proportions found in one isotopic mixing model suggesting only C3 and C4 plants. To test this refinement we used available carbon isotopic data for 11 extant herbivorous mammals from Africa. They belong to three well-defined groups/guilds: browser, mixed-feeders and grazers. Members of the grazer guild were the megaherbivore Ceratotherium simum, a specialist grazer (pie = 0.05±0.02), and the specialists mesotherbivores Equus quagga (pie = 0.09±0.10), Connochaetes taurinus (pie = 0.06±0.10), Syncerus caffer (pie = 0.07±0.09), Kollari ellipsiprymnus (pie = 0.00) and Oryx beisa (pie = 0.07), which have a diet composed mainly of C4 grass (varying from 92 % to 100 %), consumption of leaves and fruits were low (pie = 0.3% and 0.8 %, respectively). In the browser guild we have data only for Giraffa camelopardalis (pie = 0.67±0.25) feeding on 52% of leaves and 36% of fruits, and, in the mixed-feeder guild are Loxodonta africana (pie = 0.83±0.14) and Diceros bicornis (pie = 0.82±0.22), which fed similarly on C4 grass (pie = 20–22 %), fruits (pie = 36 %) and leaves (pie = 42–44 %). Hypopopontus amphibius (pie = 0.63±0.22) fed more on C4 grass (pie = 58 %), and values attributed to fruits and leaves (pie = 31 and 11 %, respectively) could be C4 aquatic plants. Our results are in agreement with the feeding habits of the meso- and megaherbivores from Africa, showing that the proposed approach opens new possibilities to refine the isotopic reconstruction of the diet of extinct large herbivorous taxa.
Regular Poster Session I (Wednesday, October 9, 2019, 4:15 - 6:15 PM)

HIGH RESOLUTION REMOTE SENSING APPLIED TO PALEONTOLOGY: CASE STUDIES FROM SATELLITE IMAGERY AND CONVENTIONAL CAMERA PHOTOS

DAVIS, Edward B., University of California Berkeley, Eugene, OR, United States of America; GHEZZO, Elena, University of Venice, Eugene, OR, United States of America; MASSIRONI, Matteo, University of Padova, Padova, Italy; MALAVASI, Stefano, University of Venice, Venice, Italy; BIANUCCI, Giovanni, Universita di Pisa, Pisa, Italy; GIONCADA, Anna, University of Pisa, Pisa, Italy; MARSH, Adam D., Petrifed Forest National Park, Petrifed Forest National Park, AZ, United States of America; PARKER, William, Petrifed Forest National Park, Petrifed Forest National Park, AZ, United States of America; HOPKINS, Samantha S., University of Oregon, Eugene, OR, United States of America

We present two remote sensing methods used to enhance the probability of fossil discovery in the field. The two methodologies depend on either the use of high-resolution satellite images or standard camera photos; the former procedure allows researchers to conduct fieldwork to identify middle- and small-size fossils that are exposed at the surface. Both approaches use intrinsic properties of fossils and their spectral signatures (i.e., the visible and invisible wavelengths in response to solar irradiation) to compare them to the same information from surrounding sedimentary matrices. Where the contrast is detectable, it is possible to infer the position of the fossil in an image of the original depositional scene. We applied this method to different paleontological contexts in terms of chronology and exposed organisms. The selected localities are the Middle Triassic of Peru (Eocene and Miocene marine mammals), the Day John Fossil Beds of Oregon, U.S.A. (Oligocene medium and small mammals), and Petrifed Forest National Forest of Arizona, U.S.A. (Upper Triassic petrified logs). After spatial computation, we obtained maps of probability predicting where fossils will be detected, and we tested our results through field collection of GPS data as well as visual mapping. This approach represents a new frontier for fieldwork in terms of discovery of remote, previously unknown fossiliferous localities. It also has important potential for prompt recovery of new specimens with a huge increase of efficiency, allowing scientists to collect specimens before the effects of weathering or illegal collecting remove the specimens from the record. Similarly, it has great potential for land managers monitoring known fossiliferous localities.

Grant Information:
This project is part of a collaboration between the University of Venice and the University of Oregon. It has received funding from the EU H2020. Grant No 788281.

U-PB (CA-TIMS) AGE CONSTRAINTS ON THE MIDDLE PERMIAN LAND VERTEBRATE EVOLUTION FROM THE MAIN KAROO BASIN, SOUTH AFRICA

DAY, Michael O., Natural History Museum, London, United Kingdom; RAMEZANI, Jahandar, MIT, Cambridge, MA, United States of America; FRAZER, Ryan, MIT, Cambridge, MA, United States of America; RUBIDGE, Bruce S., University of the Witwatersrand, Johannesburg, South Africa

The tetrapod fossil record from the Beaufort Group in the Karoo Basin is an invaluable window into tetrapod evolution from the Guadalupian (mid-Permian) to the Middle Triassic. Apart from forming a reference biostratigraphy for correlation with basins elsewhere in Gondwana and the world, the abundance of fossil material and the relative continuity of the succession mean that the Beaufort Group provides a unique natural laboratory for exploring patterns and possible drivers of evolution near the end of Paleozoic. Recently, this line of enquiry has been greatly facilitated by absolute age constraints resulting from a series of high-precision radiometric ages for several Permian assemblage zones. As of yet, the established geochronology encompasses the Lopingian (late Permian) and latest Guadalupian part of the sequence, leaving the age and duration of the two oldest and stratigraphically-thickest biozones (i.e., the Eodictynodon and Tapinocephalus assemblage zones) loosely constrained. Over the past 4 years, we have analyzed zircons from eight tuffaceous horizons from various parts of the Guadalupian Abrahamskraal Formation using the U-Pb CA-TIMS method. These have provided a series of temporally congruent ages that provide robust constraints on the age of the Tapinocephalus Assemblage Zone. They also constrain the lowest occurrence of the diapsid Dicynodon forma, which can be used to differentiate the Tapinocephalus Assemblage Zone. Our results clarify the age and duration of the Tapinocephalus Assemblage Zone within the Capitanian Stage and further enhance the timeline for the rise of large therapsids in the Permian.

Grant Information:
National Research Foundation (NRF), the DST/NRF Centre of Excellence in Palaeosciences, and the Palaeontological Scientific Trust (PAST).

Symposium: Quaternary Extinctions (Friday, October 11, 2019, 2:00 PM)

AN EXTINCT SPECIES OF PROSOBONIA FROM HENDERSON ISLAND.

DE PIETRI, Vanesa, Canterbury Museum, Christchurch, New Zealand; WORTHY, Trevor H., Flinders University, Adelaide, Australia; SCOFIELD, Paul, Canterbury Museum, Christchurch, New Zealand; COLE, Teresa, Otago University, Dunedin, New Zealand; WRAGG, Graham, Otago University, Dunedin, New Zealand

Polynesian sandpipers are small scolopacid waders restricted to remote Pacific islands of eastern Polynesia. Very little is known about their evolutionary history. Only one of the four often recognised species, the Tuamotu Sandpiper Prosobonia parvirostris, is still extant. Two of the extinct species are now only represented by paintings: the Christmas Sandpiper P. cancellata and the Mo'orea Sandpiper P. elissi. Whether these taxa are conspecific with P. parvirostris and the Tahiti Sandpiper Prosobonia leucoptera, respectively, has often been debated. This taxonomic uncertainty, arising from the lack of (type) specimens, also complicates the identification of skeletal remains from nearby islands. Bones of presumably extinct species of Prosobonia have been recovered from the Southern Cook Islands (Mangaia), the Marquesas, and Henderson Island (Pitcairn Group). Multiple skeletal elements belonging to the latter have been recorded. We describe this material in detail and compare it with a comprehensive sample of extant scolopacids and as far as it is possible, to other Polynesian sandpipers. Despite the close proximity of the Tuamotu Islands to the Pitcairn Group, the species from Henderson clearly differs from P. parvirostris in overall leg morphology and other details. Differences with P. leucoptera, represented only by one mounted specimen, are more difficult to establish and are therefore restricted to measurements. The phylogenetic relationship between species of Prosobiona and other scolopacid waders has so far been somewhat uncertain. Previous analyses of mitochondrial and nuclear gene sequence data recovered a close relationship to other sandpipers and species of Arenaria (turnstones), but exactly how they relate to members of this group has remained elusive. To further investigate the phylogenetic relationships of Polynesian sandpipers, we sequenced mitochondrial genomes for P. parvirostris and P. leucoptera. Based on molecular and morphological data, we provide an evolutionary framework for Polynesian sandpipers.

Grant Information:
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DENTAL TOPOGRAPHIC EVOLUTION IN RODENTS ACROSS THE EOCENE-OLIGOCENE BOUNDARY IN THE FAYUM DEPRESSION, EGYPT.

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On northern continents, the Eocene-Oligocene boundary (EOB) marked a change from relatively warm and humid environments to relatively cooler and drier habitats, and coincided with well-documented faunal turnover events. This climate shift and its effects on mammalian evolution are less well understood in Africa. The Fayum Depression of northern Egypt has yielded rodent fossils from several Eocene and Oligocene horizons (ranging in age from ~37 to ~29 Ma) that document the evolution of multiple lineages before and after the EOB. Here we analyze dental topographic variables in these lineages to investigate rodents’ evolutionary response to climate change in this part of northern Africa.

Crown morphologies of the second mandibular molar of 21 Fayum rodent species (δ = 3, range = 1-9) were quantified using dental topographic methods. Each tooth was micro-CT scanned and digital models were cropped along the cervical margin, simplified, and smoothed to the same resolution. The variables DNE (curvature), OPCR (complexity), RFI (relief index), and crown area were quantified and analyzed using ANOVAs, PCAs, and ancestral
reconstructions (phytools) in R. The ancestral conditions for DNE and OPCR will close to the exchange values for the entire sample, and similar to the values observed in one of the oldest Fayum phiomorphs (Protophiomyx). Multiple philopod lineages diverged from this generalized pattern of dental topography to either lower or higher complexity and curvature. The evolution of both types with higher complexity and curvature occurred in many different lineages independently; first in the gaucheamurs, and, post-dating the extinction of that group in the early Oligocene, in Metaphiomyx. In general, dental complexity is low at L-41 (terminal Eocene, ~34 Ma). Despite this, L-41 rodents display an increased diversity in tooth types following the local extinction of anomaluroid rodents, exceeding the variation observed at the ~37 Ma locality BQ-2 (with or without anomaluroids). This level of dental diversity in crown area size, but a restricted range of complexity and curvature that cluster around the mean values for the entire sample. These results suggest that rodent lineages with relatively generalized and unspecialized crown morphologies were able to persist through the climatic fluctuations of the early Oligocene, whereas highly specialized lineages were prone to extinction.

Grant Information:
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Technical Session XV (Saturday, October 12, 2019, 9:00 AM) 
THE EARLIEST KNOWN OCCURRENCES OF AN EDENTULOUS FROG AND POSSIBLE SIRENID SALAMANDER FROM THE CLOVERLY FORMATION (ALBIAN) OF WYOMING, U.S.A.

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Ongoing study of two taxon- and specimen-rich vertebrate microfossil bonebeds in the Lower Cretaceous (Albian) Cloverly Formation of the Bighorn Basin, Wyoming, U.S.A., has revealed several new lissamphibian occurrences. Herein, I report on new taxa that provide important temporal range extensions for their respective groups. First, a distinctive edentulous anuran maxilla represents the oldest-known toothless frog, predating the next-oldest example from North America, Tyrellbathratus (middle Campanian, Alberta, Canada), by approximately 30 million years, as well as the oldest edentulous anuran globally, Salenia from the Santonian–Campanian of Argentina. The new maxilla exhibits a unique combination of features that also differ from those of the third edentulous anuran from North America (Thiunon: late Campanian, Utah and late Maastrichtian, Montana and Wyoming, U.S.A.), indicating that the Cloveryl anuran represents a new genus. Second, several small atlantal centra preserve diagnostic features of the Santonian–Pleistocene salamandrid Haplolepidae, including (i) a conditionally convex anterior end of the odontoid process, and (ii) dorsoventrally depressed, medially broad, and anteriorly flattened anterior cotyles. However, the odontoid process of the Cloverly taxon differs in being shallow dorsoventrally and in having a midline vertical indentation anteriorly. If confirmed, this would mark the earliest-known occurrence of an unequivocal sirenid, extending the clade’s range back more than 25 million years. The Cloverly Formation also has yielded early representatives of other Late Cretaceous lissamphibian groups in recent years, including a new anbanerpetontid species, batrachosaurid species, and multiple toothed frogs (e.g., Scotothrynus). Taken together, these occurrences indicate a substantially older emergence of the Late Cretaceous lissamphibian fauna in North America, which retained a relatively stable higher-level composition through the end of the Maastrichtian. The co-occurrence of these taxa in two Early Cretaceous-aged fossil sites suggests that Late Cretaceous lissamphibian macroevolution in Western North America largely occurred in place, rather than as a result of sequential invasions over time.

Grant Information:
Small Grant, NMNH, Smithsonian Institution

COMPATIBILITY OF THE PATTERNING CASCADE MODEL OF TOOTH DEVELOPMENT WITH PERIPTYCHID “CONDYLARTH” MOLAR DIVERSITY

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Dental morphological characters have long been considered informative in the reconstruction of relationships among extinct taxa. However, the reliability of characters in phylogenetic analysis is reliant on their independence from other characters, and current understanding of the dental developmental program suggests that many elements of the tooth crown are not independent. The patterning cascade model (PCM), a framework for understanding the origins of cusps and cusp layouts, predicts that cusp occurrence, size, and positioning are developmentally linked as the growth of one cusp inhibits cusp formation in the surrounding region. The PCM has been shown to be consistent with cusp arrangement in individual extant taxa, but data on PCM agreement with changes across an evolutionary radiation are lacking. To this purpose, cusp number, size, and appearance were tracked across the radiation of the Periptychidae, a “condylarth” family found throughout the Paleocene and Eocene. The periptychid radiation is marked by increased changes in both body size and morphology. In general, the PCM predicts that such displacement will reduce inhibitory effects on the lingual area of the crown, and here, that is observed in the presence and degree of expression of the protostyle. On the lower molars, cingulid expression and the appearance of a mesolingual cingular cusp are similarly linked to the buccal displacement of the paracoid. The compatibility of cusp arrangement among the Periptychidae with the predictions of the PCM is useful in evaluating whether the PCM is appropriate to apply to extinct lineages, and raises questions about how to incorporate small, potentially convergent dental characters into phylogenetics.

Technical Session XX (Saturday, October 12, 2019, 2:30 PM)
3D LIMB BIOMECHANICS OF THE STEM-ARCHOSAUR EUPARKERIA CAPENSI S

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Archosaurs are a diverse group of reptiles, originating shortly before the Triassic period and radiating rapidly after the Perno-Triassic mass extinction event. In the Triassic they explored disparate morphologies in the pelvis and ankle, which led to different locomotor types and body plans throughout their evolutionary history. The diverse skeletal morphologies in Triassic archosaurs have had an undeniable influence on their locomotion, however the implications for specific functions are still poorly understood. Early archosaurs and sister taxa to Archosaurus are essential to understand the evolution of the different locomotor adaptations; however, quantitative locomotor biomechanics studies of extinct archosaurs have so far focused almost exclusively on non-avian dinosaurs. Here, we present the first detailed, quantitative and 3D investigation into the locomotory abilities of the Middle Triassic stem-archosaur Euparkeria capensis. Micro-computed tomography scans of multiple specimens from South Africa enable us to understand the limbs of Euparkeria in unprecedented depth and the characterization of previously unknown morphological features. A composite pelvic girdle and hindlimb were created to accommodate for any missing or only partially preserved elements and/or taphonomic distortion. The bones of the individual specimens were scaled isometrically to match those of the holotype. To test previous qualitative hypotheses regarding posture, gait and stance of Euparkeria, the mobility of the hindlimb was assessed by quantifying the maximal joint ranges of motion (RoM) in 3D. Two sensitivity analyses were performed to account for the unknown amount of epiphyseal cartilage and the restricting influence of soft-tissue. Due to the medially expanded femoral head and the distinct supra-acetabular rim, Euparkeria seems to have been capable of adopting a more crocodile-like “semi-crest” posture, which is further supported by our RoM analysis. The femur could be fully adducted and the feet positioned underneath the body. This is consistent with other evidence supported by our RoM analysis. The femur could be fully adducted and the feet positioned underneath the body. This is consistent with other evidence supported by our RoM analysis.
suggesting that the common ancestor of archosaurs had a similar ability to adapt to the habit of being less sprawling. However, hip (and hind limb) abduction remained feasible, so more sprawling poses were not excluded by our analysis—the hip was quite mobile. Further analyses including moment arms of muscles across the RoM are enabled by this new dataset, and with more taxa we could better reconstruct the evolution of limb function in Archosauria in the future.

Regular Poster Session III (Friday, October 11, 2019, 4:15 - 6:15 PM)

REPLACEMENT OF ARTIODACTYLS FOR PERISSODACTYLS IN THE CENOZOIC MAMMALIAN FAUNAS OF THE TIBETAN PLATEAU

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The Tibetan Plateau has an abundant and distinctive biodiversity, among which mammals hold a very important position. In the modern mammalian fauna of the Tibetan Plateau, artiodactyls are highly diversified with 27 species, but only one perissodactyl species Equus kiang lives. In geological records, on the contrary, the earliest mammalian fossil discovered in the Tibetan Plateau is a perissodactyl specimen of Brontotheriidae indet. from the Eocene deposits of the Lunpola Basin in northern Tibet. Since the Miocene, the composition of mammalian faunas has been very rich, in which perissodactyls always were important members, such as Plesiaceratherium sp. of the Early Miocene Lunboli fauna, Acercorhinus taidamenis and Hispanotherium maitivente of the Middle Miocene Ongolbulak fauna, Hipparion sibiricum and Chilotheirium izanensis of the early Late Miocene Bulung fauna, Hipparion teiliardi, H. wellohense, H. cf. H. chiai, Chiloitherium brevirostis, A. taidamenis, and Dicerorhinus ringstromii of the early Late Miocene Tsonor Tsonon fauna, Hipparion forstenae and Chilotherium szangensis of the late Late Miocene Worn fauna, Hipparion zandaense and Caelodonta thibetana of the Pliocene Zanda fauna, Proboscidippipparian pater and Rhinocerotidae indet. of the Pliocene Yuzhu fauna. Compared with the modern fauna, it shows that bovids, chalicotheres, and rhinocerotids had lived in the Tibetan Plateau, but all of them were extinct or disappeared, and only cloids survived. The success of perissodactyls in competition with artiodactyls is due to the complicated digestive system of the former, i.e., their ruminant four stomach chambers and related intestinal system. The complicated ruminant digestion is exactly the advantage of artiodactyls: they can fast eat plenty of grass and leaves in a hurry before coming of powerful predators, and then rapidly escape from a dangerous area and reach a safe place where they can be ruminant to chew carefully and digest fully. This adaptation and strategy of artiodactyls have a clear superiority in the late Cenozoic when the open grassland expanded constantly. The Tibetan Plateau reached the modern elevation in the Pliocene, and this area became open alpine grassland. As a result, artiodactyls with the ruminant advantage completely won the ecological competition with perissodactyls and the open alpine grassland. This mass death assemblage, that knowledge is critical for understanding the consequences of climate change on extinct and extant megafauna. Here, we carried out a multi-proxy approach using dental microwear texture analysis, dental mesowear, and stable carbon isotopes to assess the dietary behavior of the macropodids (kangaroos and relatives) found at the site, including the most abundant taxon, Macropus giganteus titan. All taxa examined here are dominant C3 consumers, with Sphenurus sp. consuming vegetation from denser cover (significantly lower δ13C values than all other taxa), and Diprotodon optatum consuming vegetation from more open environments than all taxa (including Macropus giganteus titan, Protemnodon sp., and Zygomantus tibialis, which all have mean δ13C values that are significantly higher and lower than Sphenurus sp. and Diprotodon optatum, respectively). Dental mesowear is indistinguishable between all macropodids, which indicates that these taxa processed similar levels of abrasives on or in vegetation consumed. Dental microwear textural attributes (anisotropy and complexity) of Macropus giganteus titan were also compared to extant Macropus giganteus specimens that died during normal years (i.e., cull specimens) or died during a pronounced drought event (i.e., skulls collected from drought killed individuals). Macropus giganteus titan is characterized as having high complexity and low anisotropy, statistically indistinguishable from extant drought killed kangaroos and consistent with the consumption of less preferred woody browse during a massive drought at Lancefield Swamp—consistent with other geochemical and taphonomic evidence. Understanding the conditions during which these macropodids and diprotodontids died is critical to understanding the vulnerabilities of ancient and modern taxa, of relevance to today. Further, this provides additional evidence that even “arid” adapted

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Symposium: Quaternary Extinctions (Friday, October 11, 2019, 2:15 PM)

DROUGHTS KILL: THE PALEOECOLOGY OF A LATE PLEISTOCENE MASS DEATH ASSEMBLAGE FROM THE LANCEFIELD SWAMP IN AUSTRALIA WITH IMPLICATIONS FOR TODAY

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The Lancefield Swamp site in Victoria, Australia is thought to be a Late Pleistocene mass death assemblage of kangaroos, with ~1000 bones per square meter recovered across a 30m diameter area. The high fatality rate of kangaroos at this site has been thought to have resulted from a drought, although evidence is equivocal. If drought was a primary driver of this mass death assemblage, that knowledge is critical for understanding the consequences of climate change on extinct and extant megafauna. Here, we carried out a multi-proxy approach using dental microwear texture analysis, dental mesowear, and stable carbon isotopes to assess the dietary behavior of the macropodids (kangaroos and relatives) and diprotodontids (giant wombat-like marsupials) found at the site, including the most abundant taxon, Macropus giganteus titan. All taxa examined here are dominant C3 consumers, with Sphenurus sp. consuming vegetation from denser cover (significantly lower δ13C values than all other taxa), and Diprotodon optatum consuming vegetation from more open environments than all taxa (including Macropus giganteus titan, Protemnodon sp., and Zygomantus tibialis, which all have mean δ13C values that are significantly higher and lower than Sphenurus sp. and Diprotodon optatum, respectively). Dental mesowear is indistinguishable between all macropodids, which indicates that these taxa processed similar levels of abrasives on or in vegetation consumed. Dental microwear textural attributes (anisotropy and complexity) of Macropus giganteus titan were also compared to extant Macropus giganteus specimens that died during normal years (i.e., cull specimens) or died during a pronounced drought event (i.e., skulls collected from drought killed individuals). Macropus giganteus titan is characterized as having high complexity and low anisotropy, statistically indistinguishable from extant drought killed kangaroos and consistent with the consumption of less preferred woody browse during a massive drought at Lancefield Swamp—consistent with other geochemical and taphonomic evidence. Understanding the conditions during which these macropodids and diprotodontids died is critical to understanding the vulnerabilities of ancient and modern taxa, of relevance to today. Further, this provides additional evidence that even "arid" adapted
animals remain vulnerable to droughts and that droughts as a major
ccontributor of megafaunal extinctions, cannot be ruled out.

Grant Information:
National Science Foundation (U.S.A.) 1053839 and 1455198.

Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM)
NEW INFORMATION ON THE HINDLIMB OF DIMETRODON TEUTONIS, A PELYCOSAURIAN-GRADe SPENACODONTID SYNSAPID FROM THE EARLY PERMIAN Bromacker LOCALITY OF CENTRAL GERMANY, AND SMALLEST KNOWN SPECIES OF DIMETRODON

DEVLIN, Kathleen R., California State University San Bernardino, San
Bernardino, CA, United States of America; SUMIDA, Stuart S., California
State University San Bernardino, San Bernardino, CA, United States of
America; BERMAN, David S., Carnegie Museum of Natural History,
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The Bromacker locality, in the Tambach Formation (middle Early Permian
Artinskian), lowermost formational unit of the Upper Rotliegend Group or
Series, in the mid-region of the Thuringian Forest of central Germany
preserves a diverse vertebrate assemblage of strictly terrestrial tetrapods
including microsaurian, amphibian, and trematop amphibians, diadectomers,
acanthodians, actinopterygii, and sarcopterygii) taxa across the Lower,
Middle, and Late Devonian. Biotic similarity analyses are used to assess the relationships of biogeographic areas and rank them within a formal hierarchy. The Temporal Area Approach (TAAPP) partitions the areas and permits considerations of changing relationships through time. The biotic similarity analyses were conducted on a database, created by the authors, of 676 genera (ca. 30,000 occurrences)
from the Late Silurian and Devonian. Consequently, this study is the largest
test of biogeographical areas undertaken in Devonian biogeography.

Results indicate that key Devonian areas have been misdiagnosed and may
not have had the same temporal range has previously believed. Accurate
diagnosis of areas is integral to biogeography. This study shows that biotic
similarity and metrics of diversity are an informative supplement to area
classification and can highlight areas for revision, rather than reinvention.
Revision is more informative than reinvention as it allows a shared and
transparent foundation upon which to build the biogeography of the future.

Grant Information:
PANGEA research centre, small research grant: $1000
Australian Government RTP: $26,000 p.a.

Colbert Prize Poster Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)
COSMOPOPOLITAN OLIGOCENE ANURAN ASSEMBLAGES: PROXIES FOR THE EFFECTS OF CLIMATE CHANGE?

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Lissamphibian assemblages are poorly represented from the Oligocene, possibly due to increased aridity and cooling across the Eocene-Oligocene transition. It is unclear if the effects of the change in climate were widespread or localized. Anurans are sensitive to climate change, both at present and in the geologic past. Therefore, an inquiry into global Oligocene anuran assemblages was performed using public databases as well as the primary literature to establish if there were trends in the representation of lifestyles between fossil assemblages. More than thirty localities were compared. Sites cannot be compared taxonomically across continents due to divergence of anuran groups during continental breakup events. However, lifestyle convergence occurs within populations and can be compared. Anurans have three distinct lifestyles: fossorial, arboreal, and semiaquatic. These lifestyles are determined by morphological adaptations to specific habitats and can be used as proxies for paleoenvironment. Using cluster analyses as well as two-way ANOVA, all localities, geographic regions, and latitudinal groups containing anurans were examined for lifestyle similarities and differences. Based on our knowledge of modern anuran habitat preferences, we expected that with an increase in widespread aridity and cooling, fossorial anurans

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would dominate, since burrowing fauna may be less affected by surface temperature and humidity changes. Our analyses revealed that there were more semiaquatic than fossorial and arboreal anurans overall between regions, latitudes, and sites. Geographically distant sites had similar assemblage compositions. Several sites consisted of only fossorial or semiaquatic anurans, but no locality had only arboreal taxa. Sites formed clusters of two to thirteen localities, except the only Australian (Kangaroo Well) and the only Canadian sites (Calf Creek), which did not cluster with any other locality and contained more arboreal taxa. Overall, there were no trends supporting increased representation of fossorial anurans. While anurans can be used as paleoenvironmental proxies, other factors such as preservation or collection biases may affect their utility, particularly for the Oligocene. The effects of climate change may be site-specific, as seen in the Fitterer Ranch anuran assemblage of North Dakota, U.S.A., which indicates Oligocene. The effects of climate change may be site-specific, as seen in the Fitterer Ranch anuran assemblage of North Dakota, U.S.A., which indicates Oligocene.

Overall, there were more semiaquatic than fossorial and temperature and humidity changes.
differences between major vertebrate lineages may introduce complications when utilizing established simulation frameworks on non-dinosaurian prey. To test whether proxy clad or proxy bone thickness affects indentation simulation results, we built upon a previous study simulating Deinonychus antirrhopus bite marks on Tenontosaurus tiliquii long bones. The original study used coelurosaur as a prey proxy; we further sampled Odocoileus virginianus (white-tailed deer), Alligator mississippiensis (American alligator), and Dromaius novaehollandiae (emu) to explore the effects of taxon selection on this type of analysis. We performed ordinary least squares (OLS) regressions on each taxon’s dataset and compared them using an analysis of covariance (ANCOVA). This failed to yield statistically significant differences between the proxies, with the caveat that support for the emu and alligator OLS regressions were comparatively low, most likely due to higher rates of breakage during simulations using these physically smaller, more thinly-walled samples. The results of an OLS regression on the pooled dataset yielded broadly comparable results to the initial study based on only cow bones. This suggests that a primary goal of simulation studies is to carefully define proxies to facilitate comparison of results.

Our results obtained from Micro-CT scanning shows that Raranimus has five therapsid synapomorphies, the most obvious being a shortened contact between the maxilla and the prefrontal. However, the presence of plesiomorphic characters, such as the presence of a precanine caniniform tooth, manifest retention of typical “pelycosaur” grade features. The maxillary canal morphology of Raranimus is comparable to that of the “pelycosaur” Varanosaurus and the baobamoushian Herpetoskylus. Overall, this confirms a basal position for Raranimus in the therapsid phylogenetic tree. New data on the age of the Qingtoushan Formation indicates a Roodian age for Raranimus, simultaneously filling “Olson’s gap” and confirming that the genus is critical in understanding the evolutionary radiation at the base of therapsids. Applying Bayesian analytical techniques for the first time on non-mammalian synapsids, we present a new hypothesis supporting previous conjectures of the basal position of Raranimus among therapsids.

Grant Information:
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Technical Session II (Wednesday, October 9, 2019, 10:45 AM)

DESCRIPTION OF FIRST NEORNITHISCHIAN DINOSAUR CRANIAL MATERIAL FROM THE ERIC THE RED WEST LOCALITY (EUMERRALLA FORMATION: UPPER APTIAN–LOWER ALBIAN), CAPE OTWAY, VICTORIA, AUSTRALIA

DUNCAN, Ruairidh J., Swinburne University of Technology, Melbourne, Australia; POROPAT, Stephen F., Swinburne University of Technology, Hawthorn, Australia; RICH, Thomas H., Museum Victoria, Melbourne, Australia

The diversity of small-bodied basal neornithischians in the Early Cretaceous dinosaur assemblages of Victoria (southeast Australia) is uncommonly high. To date, five genera have been named from two formations that together span the age of the Qingtoushan Formation indicates a Roodian age for Raranimus, approximately 20 million years (upper Barremian–lower Albian): the Eumeralla Formation (upper Aptian–lower Albian) in the Otway Basin has yielded Leaellynsaura amicographica, Atlascopcosaurus loadsi and Diluvicursor pickeringi, whereas the upper Strzelecki Group in the Gippsland Basin has produced Qantassaurus interipus and Galeonosaurus dorsiae. The holotype specimens of four of these taxa include (or solely comprise) dentulous cranial elements, and only one (L. amicographica) has been suggested to also include postcranial elements, although this association has been contested. By contrast, the fifth taxon, Diluvicursor pickeringi, lacks cranial remains, having been established on the basis of an articulated skeleton comprising a partial hind limb and tail. This specimen, from the Eric the Red West locality in Cape Otway is clearly different from the postcranial remains assigned to Leaellynsaura. Neornithischian skull elements are relatively rare in the Victorian Cretaceous, but these are particularly informative from a phylogenetic standpoint. We describe the first neornithischian cranial material from the Eric the Red West locality (Eumeralla Formation), which is stratigraphically younger than Point Lewis (the A. loadsi type site) and older than Dinosaur Cove (the L. amicographica type site). This material comprises a premaxilla, seven maxillae, eight dentaries and numerous isolated teeth. To date, Diluvicursor pickeringi is the only neornithischian therapsid to have been described from the Eric the Red West locality. Consequently, it is possible that one or more of the dentulous elements in our sample might pertain to this taxon. Although this cannot be established with certainty, what can be determined is whether any of the already named taxa from the Victorian Early Cretaceous are present at Eric the Red West. If so, then the probability that Diluvicursor is a junior synonym of an existing taxon will be able to be assessed. Preliminary observations of the specimens in question suggest that at least one of the specimens is somewhat Galeonosaurus-like. This is potentially of great significance, since the stratigraphic range of this taxon would then extend from the upper Strzelecki Group to the Eumeralla Formation, as also seems to be the case with Atlascopcosaurus...
During their rise to ecological dominance, the spatiotemporal patterns of dinosaur diversity are hypothesized to have been intrinsically linked to environmental conditions. For example, sauropodomorph dinosaurs are proposed to have been absent from low latitude regions in the Late Triassic due to ‘unstable’ climatic conditions, but in the Early Jurassic they have a more global distribution. However, these hypotheses proposing climate-driven paleoecological structuring of early dinosaur faunas remain largely untested, in part due to the absence of paleoclimatic data with sufficient temporal and spatial coverage to examine diversity across large intervals of deep time. To test hypotheses linking dinosaur diversity with climate during the Late Triassic and Early Jurassic, we used, for the first time, the results of a spatially-explicit general circulation climate model combined with a comprehensive dataset of global early dinosaur occurrences from the Paleobiology Database and a superreef of early dinosaur species relationships. We explored the effects of climate on dinosaur global distribution and evolution by mapping climatic variables as continuous characters onto the superreef, testing different potential models of climate niche evolution, and examining climate niche disparity through time. Our results document a general shift in the Early Jurassic towards warmer, dryer areas for sauropodomorphs and ornithischians. In the Late Triassic dinosaurs preferentially occupied wetter and cooler environments and sauropodomorphs occupied areas with significantly lower mean annual temperatures and high seasonal temperature ranges. However, in the Early Jurassic, dinosaurs, and sauropodomorphs specifically, occupied environments that are climatically similar to those occupied by other tetrapods. There is considerable variation in environmental conditions in the areas occupied by dinosaurs in the Late Triassic, suggesting that major clades were not restricted by climatic conditions at this time. In contrast, in the Early Jurassic, there is less variation across the major clades. Using phylogeographic generalized least squares models we found statistical support for dinosaur diversity being constrained by climatic conditions. This work provides the first quantitative support for paleoclimate as a major control on the global distribution of early dinosaurs.

Stable isotopes of reptile bioapatite have the potential to better define the climate and ecology of the early Pliocene Gray Fossil Site (GFS) in southeast Tennessee, USA. Stable carbon (δ¹³C) and oxygen (δ¹⁸O) isotope compositions from fossil Alligator tooth enamel and bone from Hesperotherium and Trachemys haugri were compared to modern Alligator mississippiensis taxa from Georgia, Trachemys scripta, and Gopherus polyphemus from Florida. The δ¹³C of carbonate from GFS fossil bioapatite is, overall, less negative than the bioapatite of modern samples. GFS δ¹⁸O Alligator values are also similar to Miocene Alligator from Florida. More negative δ¹³C in GFS bioapatite suggests cooler Pliocene temperatures in comparison to the modern dataset and Miocene Florida. Overall, stable isotopes of bone and enamel CO₂ from GFS reptiles, in combination with local mammalian faunal and pollen samples, suggests that the early Pliocene paleoclimate in eastern Tennessee was cooler than other fossil and modern sites, even sites with a similar herpetofauna. This may also explain the reduction in size of Alligator specimens from the GFS compared to larger specimens from fossil and modern sites that likely dwelled in habitats with higher median temperatures.

**Grant Information:**
Funding for analyses was provided by the Don Sundquist Center of Excellence in paleontology at East Tennessee State University.

**Regular Poster Session I (Wednesday, October 9, 2019, 4:15 - 6:15 PM)**

**STABLE ISOTOPE ANALYSES (δ¹³C, δ¹⁸O) OF FOSSIL REPTILE REMAINS FROM THE GRAY FOSSIL SITE, SOUTHERN APPALACHIANS, TENNESSEE**

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Stable isotopes of reptile bioapatite have the potential to better define the climate and ecology of the early Pliocene Gray Fossil Site (GFS) in southeast Tennessee, USA. Stable carbon (δ¹³C) and oxygen (δ¹⁸O) isotope compositions from fossil Alligator tooth enamel and bone from Hesperotherium and Trachemys haugri were compared to modern Alligator mississippiensis taxa from Georgia, Trachemys scripta, and Gopherus polyphemus from Florida. The δ¹³C of carbonate from GFS fossil bioapatite is, overall, less negative than the bioapatite of modern samples. GFS δ¹⁸O Alligator values are also similar to Miocene Alligator from Florida. More negative δ¹³C in GFS bioapatite suggests cooler Pliocene temperatures in comparison to the modern dataset and Miocene Florida. Overall, stable isotopes of bone and enamel CO₂ from GFS reptiles, in combination with local mammalian faunal and pollen samples, suggests that the early Pliocene paleoclimate in eastern Tennessee was cooler than other fossil and modern sites, even sites with a similar herpetofauna. This may also explain the reduction in size of Alligator specimens from the GFS compared to larger specimens from fossil and modern sites that likely dwelled in habitats with higher median temperatures.

**Grant Information:**
Funding for analyses was provided by the Don Sundquist Center of Excellence in paleontology at East Tennessee State University.
Regular Poster Session III (Friday, October 11, 2019, 4:15 - 6:15 PM)

**AUTOPODIA OF PHYTOSAURIA ARE CONSERVED WITHIN THE CHLADIDE AND MAY REPRESENT THE ANCESTRAL CONDITION IN ARCHOSAURIA**

EDDINS, Hannah-Marie S., Virginia Tech, Blacksburg, VA, United States of America; STOCKER, Michelle R., Virginia Tech, Blacksburg, VA, United States of America; NESBITT, Sterling J., Virginia Tech, Blacksburg, VA, United States of America

Manus and pes morphology includes key features for understanding archosaur phylogeny, evolution of anatomical systems, and biomechanical transitions. Whereas the ankle and pes received much attention, the manus has not, largely because it is poorly represented in early-diverging archosaurs and stem archosaurs. Moreover, of the few archosaur species that have a manus preserved, few have both the pes and the manus preserved in the same individual. Within Phytosauria there is a complete absence of diagnostic cranial material associated with nearly any hands and feet, which affects our knowledge of the plesiomorphic condition for Archosauromorpha. Here we describe the right manus and pes of the well-preserved phytosaur Machaeroprosopus pristinus (UCMP 27235) in order to aid in resolving details of some of the postcranial anatomy within Phytosauria and across archosaurs. UCMP 27235 is a nearly complete articulated skeleton and material includes all of the metatarsals with many associated phalanges as well as the astragalus. The astragalus has a shallow anterior hollow, and the 5th metatarsal is hooked; these characteristics are shared across Smilosuchus, Parasuchus, and Diadongosuchus, demonstrating conserved features of Phytosauria. Of the five metacarpals present, metacarpal three is longest, then the second, fourth, first, and the fifth is the shortest. The first metacarpal articulates to a dorsosventrally compressed ungual. In *M. pristinus* the length of the longest metacarpal is 0.6 that of the longest metatarsal, whereas in *Diadongosuchus* the ratio is 0.51. *M. pristinus* lacks carpals, and the only other manus of a phytosaur described in detail, that of *Parasuchus hislopi*, also lacks carpals, meaning it is possible that these structures never ossified in phytosaurs. Additionally, the absence of ossified carpals and tarsals in UCMP 27235 appears to be shared by all phytosaurs and may indicate that cartilage was a critical factor in the morphology and functionality of the hand and foot in this clade. Furthermore, it may be a signal of semiaquatic ecology. Phyosaurs appear to modify the carpals through clade evolution, but the overall architecture of the hand appears to reflect the ancestral condition for Archosauromorpha.

Regular Poster Session I (Wednesday, October 9, 2019, 4:15 - 6:15 PM)

**CHONDRICHTHYES AND OSTEICHTHYES FROM THE LATE CRETACEOUS (CAMPANIAN) ELLISDALE SITE, MONMOUTH COUNTY, NEW JERSEY**

EHRET, Dana J., New Jersey State Museum, Trenton, NJ, United States of America; CLAESON, Kerin M., Philadelphia College of Osteopathic Medicine, Philadelphia, PA, United States of America

The Ellisdale site, Monmouth County, New Jersey, represents a rich and diverse late Cretaceous (Campanian) fauna from the Marshalltown Formation. This unique locality preserves marine, freshwater and terrestrial taxa, making it one of the most complete glimpses into the paleoecology and biodiversity of the North American subcontinent of Appalachia. The site represents a mixture of marine, lagoon, estuarine and terrestrial paleoenvironments which date to the middle Campanian. When the Ellisdale site was discovered in 1980, vertebrate taxa recovered included chondrichthyans, osteichthyans, amphibians (frogs and salamanders), reptiles (lizards, turtles and crocodylians), dinosaurs and mammals. Most collecting at the site was done with traditional bulk sampling and screen-washing of matrix. While some sizeable pieces of bone and teeth are occasionally recovered, a majority of the remains are micros. After a 25 year hiatus, active collecting and research of the Ellisdale Site resumed in 2018 yielding many new specimens in a previously uncollected region. An update to the known chondrichthyan and osteichthyan fauna at Ellisdale is more diverse than previously reported. Representing both marine and freshwater taxa, cartilaginous fish remains include teeth, vertebrae, dentary, and cephalic claspers and prismatic cartilage. The diversity of chondrichthyans includes hybodontiform, squatiniform, and lamniform sharks. Batoïd remains are further refined and comprise Rajiformes, Myliobatiformes, and Sclerorhynchiformes. The chimaeriform, *Inyodus bifurcatus*, has also been recovered. Osteichthyan fossil remains include marine and freshwater teeth, vertebrae, skull and jaw material, otoliths and scales. Bony fishes identified from the Ellisdale fauna now include members of the Salmoniformes, Icthyodictyiformes, Pygocentrusiformes, Lepisosteiformes, Amiiformes and Aciencerpetiformes. A majority of the specimens, teeth in particular, are small in size consistent with a low velocity environment and the jagged fragmentary nature indicates specimens have not undergone substantial transport. Thus, given the high volume of small, complete teeth and vertebrae, it is possible that a paleoenvironmental reconstruction of the Ellisdale site might have acted as a refuge for juvenile cartilaginous and bony fishes.

Regular Poster Session III (Friday, October 11, 2019, 4:15 - 6:15 PM)

**OSTEOSARCOMA IN A DINOSAUR: A DIAGNOSIS CONFIRMED THROUGH GROSS, RADIOGRAPHIC, AND HISTOLOGIC EXAMINATION**

EKHTIARI, Sepehr, McMaster University, Hamilton, ON, Canada; CHIBA, Kentaro, Okayama, Japan; POPOVIC, Snezana, McMaster University, Hamilton, ON, Canada; CROWTHER, Rhianne, Trent University, Peterborough, ON, Canada; WOHL, Gregory R., McMaster University, Hamilton, ON, Canada; GEEN, Olivia D., McMaster University, Hamilton, ON, Canada; WONG, Andy K., University Health Network, Toronto, ON, Canada; CROWTHER, Mark, McMaster University, Hamilton, ON, Canada; PARASU, Naveen, McMaster University, Hamilton, ON, Canada; EVANS, David, The Royal Ontario Museum, Toronto, ON, Canada

Osteosarcoma is a rare tumour that affects a wide variety of animals including humans and avian theropods (birds). Others have reported findings suggestive of cancer in dinosaur bones, however no study has been able to histologically confirm the diagnosis. Here we describe a histologically confirmed case of osteosarcoma in a pathological fibula from the ceratopsian dinosaur *Centrosaurus apertus* (Ornithischia: Ceratopsidae). The specimen consists of the distal half of a pathological fibula showing neocortical neoplastic bone. Both specimens underwent micro computed tomography (micro-CT) as well as histological examination. Gross examination of the dinosaur specimen reveals a tumour that takes up the proximal half of the specimen, located about 150mm from the normal, distal end of the bone. The mass measures 155mmx92mmx61mm. The compact bony core along the tumour is quite thin in some places, suggestive of neocortex formation. The micro-CT scan of the dinosaur specimen reveals a Codman triangle, which is indicative of peristeal invasion of the tumour. The histological examination demonstrated a lack of zonation with bone maturation that would be seen if the lesion were a fracture callus, and evidence that the tumour extends throughout the cortex of the bone (confirmed on histological and radiological examination). In addition, there was evidence of extensive and multifocal penetration and destruction of the cortex by architecturally abnormal neoplastic bone with islands of normal bone visible. These findings were consistent with the human fibula specimen with a confirmed diagnosis of osteosarcoma.

The gross, radiographic, and histologic appearance of the dinosaur fibula were identical to the human osteosarcoma, despite the lack of preserved soft tissue structures in the former. We conclude that, with a similar degree of certainty as would be possible in an extant animal, this dinosaur bone demonstrates an osteosarcoma and thus represents the first histologically confirmed case of cancer in a dinosaur. Our findings confirm that dinosaurs suffered from malignancies, and suggest that the exceptionally fast-growing bones of dinosaurs may be particularly prone to the development of osteosarcoma - in the same manner that this tumour commonly occurs in humans.

Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM)

**ICHTHYOFANAL CLIPORITES FROM THE LATE EOCENE DEPOSITS OF THE FAYUM DEPRESSION, EGYPT**

EL-HARES, Marwa A., Faculty of Science, Alexandria University, Alexandria, Egypt; SALLAM, Hesham M., Mansoura University Vertebrate Paleontology Center, Mansoura University, Mansoura, Egypt; EL-MEKAWY, Desouki A., Faculty of Science, Alexandria University, Alexandria, Egypt; EL-SAYED, Sanaa, Mansoura University Vertebrate Paleontology Center, Mansoura University, Mansoura, Egypt; SEIFFERT, Erik, Keck School of Medicine, University of Southern California, Los Angeles, CA, United States of America

Cliporites (fossilized fecal pellets) often contain food residues, parasite remains and other fossils that provide an important window into paleoecology and the diets of ancient organisms. Although considerable research has been devoted to the study of Paleogene vertebrates from the Fayum Depression of Egypt, little attention has been paid to their fossilized excreta. Here we present the first study to investigate and describe cliporites of carnivorous fishes from the late Eocene Fayum site Birket Qurun Locality 2 (BQ-2). In recent years, more than 100 cliporite specimens have been collected from BQ-2. The collected material includes a wide range of sizes, shapes and both complete and fragmentary specimens. Surface-collected cliporites from BQ-2 include...
no bone fragments, which might indicate a weathering bias. Many of the BQ-2 coprolites have a variety of bone inclusions and bear outer and inner spiral morphology. The latter were generated by intestinal spiral valves and might also help to classify some of the BQ-2 fish fossils. Continued study of coprolites from BQ-2 and other Fayum localities will help to illuminate the evolution of food webs in this part of Egypt, notably across the Eocene-Oligocene boundary.

Grant Information:
Mansoura University Research Fund; Leakey Foundation

Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)

NEW PERCOMORPH FISH FROM THE LATE EOCENE QASR EL-SAGHA FORMATION, FAYUM, EGYPT

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Fossil fishes previously reported from Eocene–Oligocene formations of the Fayum Depression, Egypt, include numerous taxa, such as catfishes, lungfishes, and elasmobranchs. In addition, several percomorph fishes have been reported, with cichlids, Lates and Parachanna represented in the predominantly freshwater Jebel Qatrani Formation, and Diodon, Egertonia, Sphyraena and Xiphiorhynchus recorded from the underlying marine deposits of the Qasr el-Sagha Formation. Sphyraena and Diodon have also been recovered from the older deposits of the Birket Qaran Formation, along with two more percomorphs, Cylindracanthus and Weilerichthys. Most of these percomorph fishes are represented by fragmentary remains such as teeth, vertebrae and isolated skull bones, with cranial known only for Lates, Parachanna, Weilerichthys, and Ctenodentex, none of which have been reported from the Qasr el-Sagha Formation. Another Cenozoic percomorph taxon from Africa represented by crania is Semilikiichthys, from Miocene deposits of the Lake Albert-Lake Edward Rift and Chad. We here report a new percomorph fish collected from sediments of the type section of the Qasr el-Sagha Formation. The new specimen can be clearly distinguished from all previously reported percomorph crania from the African Cenozoic. It differs from Lates, Weilerichthys and Semilikiichthys by having a shorter and deeper ethmoid region, from Parachanna by having prominent frontoparietal crests, and from Ctenodentex by having a rectangular profile with a downturned ethmoid region and elongate basioccipital region. The rectangular profile with downturned snout is similar to serranids, but the laterally expanded vomer is more similar in morphology to the Sciaenidae, but it lacks the cavernous canals of that group. The new percomorph possesses a prominent intercalar, the parietal bones are present and there are strong fronto-parietal crests extending from the posterior edge of the parietals to the middle of the frontals above the middle of the orbit, and the supraoccipital meets the exoccipital bones ventrally. The combination of these features indicates the new fish is related to members of a restricted Perciformes (which may not be monophyletic). In addition, the specimen has a distinctly shaped vomerine head that is laterally expanded with an anterior concavity and no teeth, and has a strongly slanted occipital region with the exoccipitals extending significantly posterior to the level of the pterotics. We consider this specimen to represent a new taxon, with relationships currently unknown.

Grant Information:
Mansoura University Research Fund; Leakey Foundation

Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM)

BODY SIZE CHANGES ACROSS LIZARDS AND CROCODILYANS CORRESPOND TO CLIMATIC CHANGES THROUGH THE PALEOGENE IN THE WESTERN INTERIOR OF NORTH AMERICA

ELSHAFIE, Sara J., UC Berkeley, Berkeley, CA, United States of America

Climate is known to influence body size in living reptiles. However, body size changes in response to climatic transitions have not been investigated in extinct reptiles over deep time intervals, nor compared among higher-order groups of reptiles. Here I test the hypothesis that body size range undergoes holonic, synchronized change in lizards and crocodylians in response to climatic transitions over geologic time scales. I sampled dentary length as a proxy for body size in lizards and crocodylians from intermontane basins in the Western Interior of North America through the Paleogene, spanning several warming and cooling periods. The range of dentary length increases in both lizards and crocodylians in the early Eocene. Maximum dentary length doubles relative to the middle Paleocene (25mm vs. 60 mm in lizards, 260 mm vs. 500 mm in crocodylians) and remains elevated through the Eocene. Meanwhile, minimum dentary length remains consistent through the Paleogene in both groups (approximately 10 mm in lizards, 50 mm in crocodylians). This pattern is observed without a consistent latitudinal gradient across intermontane basins and through the Paleocene. The observed changes in maximum dentary length correspond to changes in mean annual paleotemperature in the Western Interior through the Paleogene. These results suggest that climatic changes may drive overall body size changes in lizards and crocodylians over deep time scales.

Grant Information:
This work was supported by the UC Museum of Paleontology, SVP, Geological Society of America, Evolving Earth Foundation, Sigma Xi, & Burke Museum of Natural History and Culture.

Romer Prize Session (Thursday, October 10, 2019, 8:00 AM)

HETEROGENEOUS EVOLUTIONARY RATES DURING THE FIRST HALF OF TERRESTRIAL TETRAPOD EVOLUTION

ELSLER, Armin, University of Bristol, Bristol, United Kingdom

Body size is a fundamental trait of all animals that is linked to metabolic rate, physiology, life history, and fitness. The body size of terrestrial early tetrapods, the four-limbed vertebrates, spanned several orders of magnitude during the first half of their evolutionary history (~385 Ma to 174 Ma). Previous studies of body size evolution in early tetrapods focused on single clades or did not incorporate phylogenetic information. Other studies have suggested that the long-term success of clades was related to rapid rates of body size evolution. Using a phylogenetic comparative approach here I present a comprehensive study of evolutionary rates of body size in early tetrapods including all valid terrestrial tetrapod species from the Middle Devonian to the Early Jurassic. I find overwhelming support for heterogeneous evolutionary rates of body size in terrestrial early tetrapods and a pattern akin to the Simpsonian concept of ‘quantum evolution’. Several clades of terrestrial early tetrapods are characterised by an explosive increase of evolutionary rates on single branches. These quick bursts in evolutionary rates are followed by a nearly instantaneous return to ‘baseline’ rates indicating the transition to a new adaptive zone. I find no evidence for an ‘early burst’ (EB) type of evolution with initially high evolutionary rates followed by exponentially decreasing rates. Temporal trends of evolutionary rates indicate that rates were the highest for the clade Tetrapoda during the Permo-Triassic mass extinction event (PTME). Additional rate peaks were recovered during the late Carboniferous and the early Jurassic. Archosauromorpha, which replaced temnospondyls, therapsids, and pareiasaurs as the dominant component of terrestrial ecosystems after the PTME, were significantly more likely to exhibit lower evolutionary rates than the less successful clades. Similarly, the more successful non-avian dinosaurs were more likely to have low evolutionary rates compared to pseudosuchians. Elevated evolutionary rates were therefore not necessary for the rise to dominance of archosauromorphs and dinosaurs. High rates of body size evolution do not seem to have conferred a long-term evolutionary advantage in terrestrial early tetrapods. These results call into question the general idea of clade success being linked to high evolutionary rates and resulting ‘evolvability’. Rates of body size evolution in terrestrial early tetrapods often seem to be connected to stress rather than to long-term success.

Grant Information:
This work was supported by the Natural Environment Research Council [NERC grant NE/L002434/1 and NERC BETR grant NE/P013724/1].
Modern macroscelidians are fully terrestrial, mainly insectivorous and low in diversity. Macroscelidea is known from the Eocene, but several Paleocene mammalian families are considered as stem Macroscelidea, which show a variety of different tooth morphologies. In order to infer dietary adaptations for these stem Macroscelidea, we conducted dental topology analyses, which provide quantitative data on the occlusal surface shape and are informative for dietary categorization. We used three metrics: ariaDNE (a robustly implemented algorithm for Dirichlet energy of the normal), RI (Relief Index) and 3D OPCR (3D Orientation Patch Count Rotated). Micro-CT scans of second lower molars were used to generate three-dimensional dental surface models for the analyses. For this study species from the Wapiti Formation, which have been assigned to the ichnospecies Bellatoripes fredlundi, yet they were likely produced by earlier ontogenetic stages of the same track maker based on stratigraphic near-equivalence and geographic proximity. These tracks provide insights into the pedal ontology of a tyrannosaurid and support hypotheses of ontogenetic and shifts that postulate greater agility and possible cursoriality for juveniles. Relatively increased digit width and an expanded heel pad at larger track lengths also agree with previous skeletal observations that indicate proportionately greater burden in tyrannosaurs during adulthood. Overall, the locality is congruent with the body fossil record of the upper Wapiti Formation, which is indicative of a hadrosaurid-dominated assemblage on the high paleolatitude (~63°N) floodplains of central-western Alberta during the late Campanian.

Grant Information:
This work was supported by an RTP scholarship from the Australian Government and an endowment fund awarded to C. S. by the River of Death and Discovery Dinosaur Museum Society.

Technical Session IV (Wednesday, October 9, 2019, 4:00 PM)

A UNIVERSAL POWER LAW FOR THE GROWTH AND FORM OF TEETH, CLAWS, HORNs, THORNS AND BEAKS

EVANS, Alistair R., Monash University, Melbourne, Australia; POLLOCK, Talitha L., Monash University, Melbourne, Australia; CLEUREN, Silke G., Monash University, Melbourne, Australia; PARKER, William M., Monash University, Melbourne, Australia; RICHARDS, Hazel L., Monash University, Melbourne, Australia; WILSON, Tim E., Monash University, Monash University, Australia; HOCKING, David P., Museums Victoria, Melbourne, Australia; ADAMS, Justin W., Monash University, Melbourne, Australia

An immense diversity of pointed structures is found throughout biological systems, including teeth, claws, horns, thorns and beaks. While the shapes of some of these structures have been attributed to a logarithmic (or equiangular) spiral, these structures generally do not fit this pattern very well. Here we show a new model of growth and shape based on a power law that generates accurate representations of teeth from all vertebrate groups (Mammalia [Marsupialia, Artiodactyla, Carnivora, Cetacea, Chiroptera, Primates, Proboscidea], Reptilia [Squamata, Dinosauria, Sauropsyergia, Ichthyosauria], Aves [Aves], Reptilia, Reptilia, and Chordichthyces). For instance, growth of unicusp teeth as diverse as those found in Homo sapiens (R² = 0.998), Smilodon fatalis (R² = 0.999), Tyrannosaurus rex (R² = 0.998), and Carcharocles megalodon (R² = 0.997) are extremely well described by this model. It can even be used to describe the growth of individual cusps on multicusp teeth (such as human molars or seal postcanines), as well as the variation of tooth shape along the tooth row (such as crocodiles and seals) and within species. Additionally, the model can predict the original shape and length of worn and broken teeth, and represents the shape of cusps more accurately than existing in situ models of tooth development. We view this model as the third general model of tooth development, along with the pachygnathic cascade model for cusp number and spacing, and the inhibitory cascade model that predicts relative tooth size. Beyond dentitions, the model also depicts growth of claws (Mammalia and Dinosauria), horns (Artiodactyla, Dinosauria and Testudines), beaks (Aves and Cephalopoda), chelicera fangs (Arachnida), and thorns (Plants). This model provides a mechanistic basis for the generation of these pointed structures across the tree of life.

Grant Information:
Australian Research Council ARC FT130100968 and DP18010797 to ARE.

Romer Prize Session (Thursday, October 10, 2019, 9:15 AM)

NEW INSIGHTS INTO THE EVOLUTION OF SECONDARILY MARINE LIFESTYLES, MARINE ADAPTATION, AND DIVERSIFICATION OF TURTLES

EVERS, Serjoscha W., University of Oxford, Oxford, United Kingdom

Evolutionary transitions to marine habitats occurred frequently among Mesozoic reptiles, but chelonian sea turtles are the only clade that survives to the present. Thus, chelonians provide the chance to investigate macroevolutionary questions, such as the mode and tempo of morphological evolution during this ecololical transition informed by total evidence approaches that integrate fossil and recent data. However, uncertainties about turtle phylogeny, particularly the relationships of several secondarily marine groups from the Mesozoic have prohibited a rigorous assessment of divergence times of marine clades, and of patterns of flipper evolution. I address these issues by reconciling previously available data with novel observations based of a large database of 3D cranial models derived from tracks from the site are smaller than previously described examples from the Wapiti Formation, which have been assigned to the ichnospecies Bellatoripes fredlundi.
protostegids. The general flipper morphology of chelonioids was established. Angolachelonians comprise all non-pleurodiran marine Mesozoic–Paleogene taxa and 355 characters, formulated using a consistent coding strategy that >150 CT scans of living and extinct turtles. This resulted in a dataset of 120 turtles. The chelonioid crown-group evolved during the early Late Cretaceous, secondarily marine lifestyle: chelonioids and angolachelonians.

Bayesian phylogenetic analyses, incorporating explicit statistical hypothesis accounts for hierarchical homologies of observed variation. Par simony and Americhelydians, i.e., chelonioids plus their extant sister clade, the chelydrids, are inferred to have a North American origin, but geographic expansion of protostegids occurred rapidly during the Early Cretaceous. The inference of an earlier diversification of americhelydians implies that crown-clades of turtles in general diversified earlier and faster than previously thought. My findings indicate that at least three independent origins of clades of turtles in general diversified earlier and faster than previously thought. Evolution of the main branches of Amniota.

The brain has a primacy in early cranial development. Extant birds underwent an enlargement of the brain in comparison to other reptiles. This process caused important changes to the bird skull, in particular the skull roof. However, a link between the brain regions and the skull roof elements has never been formally addressed. CT scanning, immunofluorescence and confocal imaging were combined to track mesenchymal condensation and ossification patterns of the skull roof along the development of the brain in a developmental series of diapsids, including squamates, stem and crown archosaurs. Our results demonstrate that rate of cranial evolution during the Late Cretaceous and the Paleocene-Eocene thermal maxima. These two warming events correspond to diversification and dispersal events in Caudata, as well as in several other clades, such as angiosperms, arthropods, and birds. The high diversification and rate of morphological evolution observed approximately 50 million years ago also correspond to the sole invasion of tropical regions by plethodontids, as well as to their transcontinental dispersion in the northern hemisphere. We also demonstrate that different life history strategies show distinct rates of evolution, with paedomorphic and biphasic species showing higher rates of evolution than direct developers. Interestingly, biphasic species do not appear to have achieved greater disparity than direct developers, despite their higher rate of evolution, suggesting a constraint that limits their exploration of cranial morphospace relative to the highly disparate and fast evolving paedomorphic species.

Our results demonstrate that rate of salamander cranial shape evolution increases during episodes of global warming, alongside increases in taxonomic diversification and geographic dispersal. Further analysis of fine-scale patterns of climate change, niche availability, and their interactions with life history and ecology will provide important new insights into the causes of these increased rates of evolution, diversification, and dispersal in Caudata during periods of global warming.

Preparators' Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)

REMOVING ASBESTOS FROM RECONSTRUCTED AREAS OF SPECIMENS AT THE SMITHSONIAN MUSEUM OF NATURAL HISTORY SAFELY AND WITH THE LEAST IMPACT TO THE SPECIMEN.

FAIR, Matthew R., Research Casting International, Carrying Place, ON, Canada; MAY, Peter J., Research Casting International, Trenton, ON, Canada; JABO, Steve J., Smithsonian Institution National Museum of Natural History, Washington, DC, United States of America; DALLMAN, Garth, Research Casting International, Trenton, ON, Canada; MADILL, Amelia S., Research Casting International, Trenton, ON, Canada

During the recent renovation of the fossil halls at the Smithsonian Institution’s National Museum of Natural History, the process of testing for asbestos was done prior to disarticulation of the existing skeletal mounts. Three mounts tested positive for asbestos containing building material (ACBM): two Eremotherium rasconi skeletons and a Mammut americanum skeleton. These specimens contained a substance with 20 to 25% Chrysotile asbestos fiber. The ACBM was within a sculpting material (“guk”) made of plaster, papier-mâché, and Alvar (polystyrene acetate), with asbestos fibers added to strengthen it. Guk was used in the NMNH prep lab in the 1960’s and ’70’s to reconstruct and repair fossils, and in some cases to fill the gap where individual bones

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articulated. We quickly made ourselves familiar with OSHA asbestos regulations, followed by multiple certification courses for asbestos removal and supervision. It was determined that the project would involve two separate setups for asbestos removal. A temporary enclosure was built at the museum to disarticulate the skeletons, and a permanent enclosure was built at RCT’s facility where the fossils could have the asbestos remediated. The permanent facility included a decontamination shower for staff to clean the tools and themselves.

Throughout this process, several methods and procedures for isolating areas of the individual fossil elements that contained ACBM were developed. All of the procedures were done using the proper personal protective equipment (PPE). Glove bags were used for the majority of the work to further prevent and control the release of asbestos fibers. This involved inserting the fossil into a plastic and rubber bag and working on the area with the ACBM. The other parts of the fossil remained outside of the bag, removing them from the wetting process used to prevent the asbestos fibers from becoming airborne. Larger pieces were remediated in the open in the permanent enclosure. In this method, the material was removed using a combination of hand tools, such as knives, and hammers and chisels. These tools were used so as to not disturb the area during the remediation process. Power tools and air scribes generate airborne particulates, and are not to be used according to the OSHA guidelines. The successful goal of these methods was to reduce the amount of impact the remediation had on the fossils, while still maintaining a safe work environment.

Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)

A NEW SPECIES OF SAURICHTHYS (ACTINOPTERYGII: SAURICHTHYIDEA) EXTENDS ITS GROUP’S RANGE TO THE LATE TRIASSIC OF EASTERN TETHYS

FANG, Gengyu, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, China; LU, Feixiang, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Nanjing, China

The saurichthyiform fishes are a kind of ray-finned fishes which lived from the Upper Permian to the Middle Jurassic. Featured with a pointed rostrum and a streamlined long and slender body plan, they are considered among the top predators of the Mesozoic oceanic ecosystem. They were greatly diversified during the Middle Triassic, both in eastern and western Tethys, but appeared to vanish thereafter on both sides, with no undoubted record in the eastern Tethys for a long time. Recently, a new material of Saurichthys was found from the Carnian (Upper Triassic) of Yunnan province, southwestern China. This Locality yielded abundant fossil, such as marine reptiles, crinoids and countless ammonites. The material includes a nearly complete skull preserved together with some ammainites and bivalves. Based on the fairly long rostrum and some distinguishing features of the opercular bones, it is assigned as a new species of Saurichthys. The ammonites suggest a Carnian (Late Triassic) age for the fish.

The saurichthyiform fishes survived the end-Permian mass extinction and evolved rapidly shortly after that crisis to accomplish a world-wide distribution in the early Triassic. They reached the diversity peak in the Carnian (Upper Triassic) of Yunnan province, southwestern China. This Locality yielded abundant fossil, such as marine reptiles, crinoids and countless ammonites. The material includes a nearly complete skull preserved together with some ammainites and bivalves. Based on the fairly long rostrum and some distinguishing features of the opercular bones, it is assigned as a new species of Saurichthys. The ammonites suggest a Carnian (Late Triassic) age for the fish.

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was systematically excavated and yields three stratigraphic horizons. The second location includes three Pliocene fluvial sites at Chinchilla, northern Darling Downs, where the fossils lack detailed stratigraphic context. Kings Creek fossil trace element signatures are mostly consistent, regardless of stratigraphic position or taphonomy, suggesting a similar diagenetic setting during deposition and fossilization. However, despite the consistent signature, variation was observed in some specimens from the uppermost horizon suggesting that some reworking may have occurred. Chinchilla fossil trace element signatures are more variable compared to Kings Creek, suggesting more complex site depositional processes and fossilization settings. The three Chinchilla sites share similar trace element signature variability, however, site-specific signatures also occur. There is a notable difference in geochemical signatures between the Chinchilla and Kings Creek datasets. The variability between the two localities demonstrates that trace element analyses can be effectively used to proveance Darling Downs specimens of varying ages from the existing historic fossil collections. This geochemical approach could also easily be adopted across the planet for other collections where fossils remain poorly provenanced.

Grant Information:
Limnean Society Betty Mayne Scientific Research Fund; ARC grants (DP120101752, DE120101533, LE0989067); and the Ian Potter Foundation.

Preparators’ Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)
THE USE OF TRADITIONAL MORTARS AND HIDROFUGANTS IN RESTORATION AND PRESERVATION OF PALEONTOLOGICAL SITES
FERRER VENTURA, Mireia, University of La Rioja, Logroño, La Rioja, Spain; TORICES, Angelica, University of La Rioja, Logroño, La Rioja, Spain; NAVARRO LORBÉS, Pablo, Polytechnic University of Valencia, Spain; SAN JUAN PALACIOS, Raúl, University of La Rioja, Logroño, La Rioja, Spain; NAVARRO LORBIÉS, Pablo, University of La Rioja, Logroño, La Rioja, Spain

La Rioja (Spain) is one of the richest areas of the world in terms of paleontological record, with almost 10000 dinosaur footprints and around 1000 trackways, in a surface of just around 5000 km². This work presents the analysis and both corrective and preventive actions carried out in “La Virgen del Campo”, one of the best-known sites of this area, found in the Enciso locality (La Rioja, Spain). Many pathologies were identified in this site, that could be causing its deterioration. First, superficial pathologies such as cracks and fractures were analyzed. They are especially important in this site conservation because of the high temperature and humidity variation, in addition to rainfall erosion and other factors that could be damaging the rock and the footprints in it. The materials and methods used in paleontological sites had varied in space and time due to the lack of a uniform action protocol. Considering the advances in conservation and preservation of stone monument heritage, a new protocol for La Rioja paleontological sites is being developed.

With this information, we performed laboratory tests on samples taken from the same geological layers of the site to verify the proper functioning of the material before the restoration work in the site. As we know the pathologies and the harm of the site, we can choose the proper materials doing the appropriated tests. There are many researches about the durability and reversibility of lime mortars. We studied different kind of mortars made of hydraulic lime and different types of aggregates, such as sand, silica and calcium carbonate. Depending on the wanted or needed result, we may choose one kind or another.

In addition, there is a problem of accumulation of water in the footprints and cracks. Moreover, sometimes the water leaks under the geological layer. This leaking is problematic because it could erode or dissolve the layer or even induce mineral precipitation that could result in fractures and cracks to the site. For this reason, we decided to test and use a hydrofugant product. After all the laboratory tests, we performed the same analysis near the site but in the rock itself, not in samples. We applied the different mortars depending on the needs. For the correct application of the mortars by the work team, we designed a diagram with instructions for every possibility. Nowadays we are monitoring the environmental conditions and results of our work, so we can determine the efficiency and durability of this restoration in the future and add some changes if the site needs it.

Technical Session V (Wednesday, October 9, 2019, 2:15 PM)
CLIMATIC SHIFTS DROVE MAJOR CONTRACTIONS IN AVIAN LATITUDINAL DISTRIBUTIONS THROUGHOUT THE CENOZOIC
FIELD, Daniel J., University of Cambridge, Cambridge, United Kingdom; SAUPE, Erin E., University of Oxford, Oxford, United Kingdom

Numerous higher-level avian clades are restricted to Earth’s lower latitudes, leading to historical biogeographic reconstructions favoring a Gondwanan origin of crown birds and many deep subclades. However, such ‘tropical-restricted’ clades are frequently represented by stem-lineage fossils well outside the ranges of their closest living relatives, often on northern continents.

To assess the drivers of these geographic disjunctions, we combined ecological niche modeling, paleoclimate models, and the early Cenozoic fossil record to examine the influence of climatic change on avian geographic distributions over the last ~56 million years. By modeling the distribution of suitable habitable area through time, we illustrate that most high latitude Paleogene fossil-bearing localities would have been suitable for occupancy by present-day ‘tropical’ clade representatives when the fossils were deposited. Potentially-suitable habitat for numerous higher-level clades is inferred to have become progressively restricted towards the tropics throughout the Cenozoic, culminating in relatively narrow circumtropical distributions in the present day. This pattern manifests in a pronounced sharpening of the avian latitudinal diversity gradient through the Paleogene and Neogene.

Our results support coarse-scale niche conservatism at the clade level, and are consistent with a scenario whereby climate change over geological timescales has largely dictated the geographic distributions of major avian clades. The distinctive modern bias towards high avian diversity at tropical latitudes for most hierarchical taxonomic levels may therefore represent a relatively recent phenomenon, overprinting a complex biogeographic history characterized by dramatic geographic range shifts driven by Earth’s changing climate and intercontinental dispersal. Earth’s current climatic trajectory portends a return to a megathermal state, which may dramatically influence the geographic distributions of many range-restricted extant clades.

Education and Outreach Poster Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)
CREATING SCIENCE OUTREACH MATERIALS AS A TOOL FOR SCIENTIFIC LITERACY IN HIGH SCHOOL: EXAMPLES FROM PALEONTOLOGY AND NATURAL HISTORY
FIGUEIREDO, Rodrigo G., UFES, Alegre, Brazil

Contemporary society is deeply immersed in scientific and technological cultures and, thus, access to scientific cultural goods and skills is fundamental to ensuring the full citizenship of the population. The school is the main space responsible for literacy in science, where the possibilities of mediation of new and old knowledges by teachers are open. However, it is important to note that there is often an epistemological rupture between common and scientific knowledge, which is reflected in the use of different languages and discourses by its practitioners. The consequence of this strangeness is often manifested as low levels of scientific literacy and little interest in science. The case of natural history is even more serious, as there is a growing disconnection between man and nature. The interface between students’ previous conceptions about science, and everyday language is a solution for constructing scientific literacy in natural history. The Universidade Federal do Espírito Santo (UFES) and Irma Maria Horta State School developed in partnership the project “Languages, textual genres and scientific literacy in natural sciences: Paleontology as an integrating discipline”. Ten high school students acted as fellows in this Junior Scientific Initiation Program creating science outreach material with an easy daily-life language and focusing on internet and social media. The students gathered in two-hour meetings, twice a week, to read about popular science, to write texts, and scripts for podcasts, to record audio, and to create board games about evolution and paleontology. Each month a new topic was discussed in the meetings, always a suggestion of the students. Among the subjects studied were the diversity of past life, major extinctions, evolution, dynamics of planet Earth, among others. Several outreach materials were created by the students (texts, podcasts, games) and made freely available on the internet (in Brazilian Portuguese) to any interested person.

Grant Information:
FAPES grant 0369/2016
The Late Cretaceous of Alaska records a remarkably diverse fossil vertebrate fauna across much of the region. Within this fauna, hadrosaurs and ceratopsians are the most commonly found. As the largest-bodied herbivores, these two dinosaurs are likely the keystone species and their presence played a role in structuring this ancient ecosystem. The richest rock units in terms of dinosaur remains are the Prince Creek Formation (PCF), North Slope, the lower Cantwell Formation (LCF), Denali National Park, and the Chignik Formation (CF), Aniakchak National Monument, and together provide an unparalleled opportunity to examine an ancient high-latitude terrestrial ecosystem from a regional perspective.

The PCF consists primarily of small distributary channels, crevasse splays, small ponds and abundant paleosols. Megafossil remains are uncommon, but paleosols contain an abundant palynoflora. The rich dinosaur record is known largely from skeletal remains. The PCF, located at 75-85 °N palaeolatitude, had a MAP of -3.6 °C. An average MAP value of 1318 ± 181 mm/yr was obtained from paleosol geochemical calculations. MAP estimates calculated from d13C data yield a range of 350-1200 mm/yr and a high range of 1000-3900 mm/yr.

The LCF consists primarily of axial braided rivers, alluvial fans, floodplains, ponds and small lakes. Abundant plant megafossils are present but fossil pollen recovery is poor. A rich invertebrate and dinosaurian ichnofauna is known from the LCF. The LCF, located at a palaeolatitude of 65-75 °N, had a MAP of ~7-8 °C. MAP estimates calculated from d13C data yield a range of 168-470 mm/yr during the MME, 353-1050 mm/yr before the MME, and 475-1451 mm/yr after the MME. The CF is a cyclic succession of sedimentary rocks representing shallow marine environments in the lower part and predominantly non-marine conglomerate, sandstone, mudstone and coal. The CF, located at a palaeolatitude of 56-57 °N, had a MAT of ~15 °C. Woody fragments from the CF were measured for their carbon isotopic composition to relate d13C to mean annual precipitation. The sample analyzed from the Chignik Fm. was -24.0% vs. VPDB. The CF sample suggests a MAP value of 822 mm/year. Relative abundances of hadrosaurs and ceratopsians vary somewhat along this north-south transect and different environment. Both dinosaurs are abundant from the PCF and LCF, but the CF is dominated by hadrosaurs. We suggest that the paleoclimatic and paleoenvironmental variances observed played a role in the large-bodied herbivore ecological structure of the ancient north.

Diverse clades of reptiles occupied the upper levels of marine food chains in the Mesozoic, an iconic peculiarity of that Era which abruptly ended at the K-Pg boundary. In both Patagonia and southern Australia during the Early Cretaceous, a remarkable diversity of marine reptiles flourished, including several named species, some based on relatively complete cranial remains, a rigorous systematic revision is needed. Prosqualodon arctirostris, sister to Phoberodon arctirostris (Chilcatay Formation, Patagonia, Argentina), in which it is probably congeneric. Parsimony analysis of these specimens using a published morphological matrix resulted in: a clade of Australian specimens + Phoberodon arctirostris, sister to Intiectus vertici (Chilcatay Formation, Patagonia, Peru); the latter clade being sister to crown Odontoceti; Squalodon calvertensis and Prospalodon within Platanistoidea, thus part of crown Odontoceti. These results corroborate some previous analyses showing that Squalodontidae is paraphyletic and in dire need of systematic revision. The co-occurrence of Phoberodon (or Phoberodon-like species) and Prospalodon in both Patagonia and southern Australia during the Early Cretaceous suggests a commonality in the cetacean fauna of austral latitudes during the early Miocene.

Diverse clades of reptiles occupied the upper levels of marine food chains in the Mesozoic, an iconic peculiarity of that Era which abruptly ended at the Cretaceous-Paleogene boundary. Among these, several long-lived groups became extinct long before the end of the Cretaceous, as other groups concomitantly radiated, resulting in substantial turnover events within the Mesozoic itself. However, the biodiversity dynamics of Mesozoic marine reptiles as a whole have never been computed, so the evolution of their global diversity is poorly understood. We assembled comprehensive cladistic datasets for the major groups of Jurassic-Cretaceous marine reptiles: Ichthyosaurus, Plesiosaurus, Mosasauridae, Thalattosuchia, Dryptosauridae, Hesperornithiformes, Platypterygius, and Cryptodira. We analysed each of these datasets under a common methodological framework (implied weighting maximum parsimony) and then created 1000 supertrees randomly sampling the most parsimonious trees from each clade prior to time-calibration, under a Bayesian framework (Hedman’s algorithm). We then computed the phylogenetic diversity of Mesoic marine reptiles through time and assessed Fritz & Purvis’D to measure the phylogenetic clustering of extinction at each stage boundary of the earliest Jurassic-earliest Paleogene interval. Finally, we calculated the evolution of per-clade disparity using the cladistic datasets.

Our results highlight important episodes of turnover in Middle Jurassic and earliest Cretaceous. Both are marked by high levels of extinction selectivity and temporally reduced phylogenetic diversity; the severity of some of these events surpasses that of the K-Pg boundary extinction. The effects of a potential ‘Jurassic-Cretaceous boundary extinction’ were not prominent at the Valanginian, more than 6 Ma after the boundary itself. Furthermore, with more than 110 inferred lineages in the Albian, marine tetrapods were more speciose during the ‘middle’ Cretaceous than are today’s limited marine tetrapods. This was followed by a gradual decline, as ichthyosaurs, plesiosaurs, and early polyptertylids vanished, in a series of non-selective (i.e., statistically unclustered) extinctions. However, the disparity of each individual clade remains roughly constant or increases during the Late Cretaceous. The latter phenomenon suggests that phylogenetically clustered in our dataset, consistent with the high ecological impact of the Cretaceous-Paleogene event for marine communities.

Grant Information:

MIS grant (#F.4511.19), F.R.S.–FNRS, Belgium
DIETARY AND HABITAT PARTITIONING OF JURASSIC MARINE REPTILE ECOSYSTEMS

FOFFA, Davide, National Museums Scotland, Edinburgh, United Kingdom

Niche partitioning is a fundamental ecological concept that enables ecosystems to support diversified trophic networks. In modern oceans, diverse predator sympathy is facilitated by cranio-dental morphological differentiation, which is intrinsically linked to diet preferences. This notion offers the framework to investigate assembly rules and ecology across geological time. However, to date paleoecological studies of large marine predators have largely been speculative, primarily based on qualitative evidence, and superficial analogies. In this study I investigate the ecology of an exceptionally diverse Jurassic marine reptile fossil assemblage (from the Sub-Boreal Seaway of the modern United Kingdom) across a ~18 million-year interval of significant climatic and habitat perturbations. The results reveal unprecedently detailed evolutionary patterns, and long-term evolution of ecosystems, and predict how they can adjust to current perturbations.

Grant Information:
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A ZIPHIID-LIKE PLATANISTOID DOLPHIN FROM THE OTEKAIKE LIMESTONE (WAITAKIAN STAGE, LATEST Oligocene), HAKATARAMEA VALLEY, NEW ZEALAND

FORDYCE, Robert E., Université of Otago, Dunedin, New Zealand

A new dolphin from the Otekaike Limestone, Hakataramea Valley, has specialised jaws and a reduced dentition, consistent with a suction-feeding life mode – the first such odontocete from the New Zealand mid-Cenozoic. The dolphin is convergently similar in skull form to living, suction-feeding, beaked whales (Ziphiiidae). Dolphin OU 22540 is from the bioecologic upper Otekaike Limestone, just above a mollusc-rich shellbed (Waitakian, latest Oligocene). Massive bedding, well-preserved para-autochthonous macroinvertebrates, and associated skeletons of vertebrates, suggest a mid-shelf setting with limited traction currents below storm wave base. OU 22540 has a beak-like rostrum with massive maxillae, but no alveoli. Each mandible is straight-edged with an alveolar groove but lacks teeth in situ. The face around the nares is strongly asymmetrical and elevated, consistent with well-developed nasal muscles. Similar features occur in beaked whales (Ziphiiidae), albeit constructed differently. Other features differ from those of Ziphiiidae: the lacrimalgular is fused; the curved paraballary sulcus on the upper teeth articulates archaic platanistoids; the posterior has a prominent articual process, the bulla lacks an enlarged posterior process; and the pterygoid sinus fossa is not enlarged and has a rod-like hamulus. Phylogenetic analysis with 88 OTUs and 284 characters (parsimony, unrooted, equal weights) gave a consensus tree with OU 22540 at the base of the Platanistidae +Squalodontidae + Waipatiidae + Porpoidea. Dolphin OU 22540 is from a shelf setting facing the Southern Ocean and surrounding the archipelago of Zealandia. Given this setting, was the dolphin a neritic species? Or might its ziphiiid-like skull form imply pelagic foraging beyond the shelf break, and perhaps deep-diving?

Technical Session I (Wednesday, October 9, 2019, 9:45 AM)

REASSESSING THE MOSASAUR PECTORAL GIRDLE AND ITS ROLE IN SWIMMING FUNCTION: NOT ENTIRELY WHALE-LIKE AFTER ALL

FORMOSO, Kiersten K., University of Southern California, Los Angeles, CA, United States of America; HABIB, Michael, Keck School of Medicine of USC, Los Angeles, CA, United States of America; BOTTGER, David, University of Southern California, Los Angeles, CA, United States of America
Mosasaurs are charismatic marine squamates that were prominent global predators in the Late Cretaceous. Two clades (Mosasaurinae (Mosasaurus, Plotosaurus, Clidastes) and Russellosaurina (Tylosaurus, Platecarpus, Tethysaurus)) make up a bulk of the known taxa. Mosasaurs, like other derived aquatic tetrapods, exhibit convergent marine morphology including streamlined bodies, enclosed paddles, and caudal flukes. With regards to swimming mechanics, most recent functional analyses have likened mosasaurs to whales based on morphological similarities. However, both Mosasaurinae and Russellosaurina have distinct massive pectoral girdles which whales lack, and forelimbs placed more ventrally than in both odontocetes and mysticetes. We analyzed the morphology of the pectoral girdle across both mosasaur clades and suggest that they were actively utilizing their forelimbs for aquatic locomotion. Past studies did make note of the large mosasaurian pectoral girdle, but pectoral limb propulsion models have typically been considered less robustly supported than caudal propulsion models. However, given the morphology of the mosasaur pectoral girdle, a dual-module propulsive system, in which both the caudal and pectoral limbs contribute significantly to propulsion, remains plausible. LACM 397, a Plotosaurus (Nobibrara Formation) has exceptional preservation of the pectoral girdle, including the cartilaginous extensions of the scapulae. Based on the large, nearly equal surface areas of the coracoid and scapula in LACM 397, our results indicate that the adduction power would be at least double that of the abduction power at the shoulder. The craniocaudally elongate sternum of LACM 397 (and other mosasaurs) is indicative of significant preclude use of the pectoral limbs for control and stabilization during “feathered” stroke similar to modern sea lions and fur seals. This does not been used in drag-based propulsion for fast starts. They may also have been girdles, we suggest that mosasaurs may have utilized a dual caudal and dual-module propulsive system, in which both the caudal and pectoral girdles, including the cartilaginous extensions of the scapulae. Based on the large, nearly equal surface areas of the coracoid and scapula in LACM 397, our results indicate that the adduction power would be at least double that of the abduction power at the shoulder. The craniocaudally elongate sternum of LACM 397 (and other mosasaurs) is indicative of significant retraction capacity at the shoulder, as well. The shape of the glemoid is consistent with this interpretation. The pectoral limbs in mosasaurs could have been used in drag-based propulsion for fast starts. They may also have been used in a coordinated fashion with the caudal module, perhaps using a “feathered” stroke similar to modern sea lions and fur seals. This does not preclude use of the pectoral limbs for control and stabilization during sustained swimming, particularly at high speeds. Given their large pectoral girdles, we suggest that mosasaurs may have utilized a dual caudal and forelimb propulsion system not seen in extant animals. With this interpretation it reveals the importance in acknowledging that when reconstructing the life modes of ancient organisms they may be a chimera of multiple analogs.

Grant Information:
This material is based upon work supported by the National Science Foundation Graduate Research Fellowship Program.

Regular Poster Session III (Friday, October 11, 2019, 4:15 - 6:15 PM)
A NEW NEORNITHISCHIAN (CERAPODAN?) DINOSAUR FROM THE OXOFORDIAN SHISHIGUO FORMATION OF CHINA: WHAT IS AN ORNITHOPOD?
FORSTER, Catherine A., George Washington Univ, Washington, DC, United States of America; SPENCER, Marc R., George Washington University, Washington, DC, United States of America; POOLE, Karen E., Central Michigan University, Mount Pleasant, MI, United States of America; CLARK, James M., George Washington University, Washington, DC, United States of America; XU, Xing, Institute of Vertebrate Paleontology & Paleanthropology, Beijing, China
Numerous partial to complete individuals of a new neornithischian dinosaur have been collected from the early Late Jurassic Shishiguo Formation in northwestern China. These specimens are distinct from the scanty remains of “Gongbusaurus” wucaivainensi, a putative neornithischian from the same formation. The new taxon includes an ossified clavicle and, uniquely, a patellar sesamoid and trioblate maxillary and dentary teeth. Cooval taxa from the Lower Shaximiao Formation in Sichuan, China (Hexinlusaurus, Agilisaurus, Yandusaurus), regarded in many recent analyses as falling outside of Cerapoda (Marginocephalia + Ornithopoda), lack many characters distributed among ornithopods that are present in our new Shishiguo taxon, including a large hooked coracoid process, a small quadratojugal foramen, narrow and elongate frontals, strong epipophyseal ridges on the postzygapophyses of anterior cervical vertebrae, and a well-defined and elongate femoral neck with a deep femoral capital sulcus. However, our new taxon also retains some plesiomorphic character states relative to more basal ornithopods such as having five sacral vertebrae, and a short, narrow lesser trochanter on the femur. Recent analyses of neornithischian dinosaurs are not in agreement over the composition of Ornithopoda or Cerapoda, or the distribution of characters along this neornithischian branch. Putative synapomorphies of Ornithopoda vary from study to study, as does the composition of the clade. In some studies “orn. ornithopoda” such as Thescelosaurus and Orodromes have been pulled out of Cerapoda as basal neornithischians, while other studies recover a more inclusive monophyletic Ornithopoda. The current consensus of basal neornithischian and cerapod phylogeny is poorly resolved. New taxa such as this that exhibit some, but not all, characters used in many studies to define Ornithopoda may help unclutter some of the resolution at the base of the cerapodan tree and provide a clearer diagnosis for Ornithopoda.

Grant Information:
This research is supported by grants from the National Geographic Society and the National Science Foundation (NSF EAR 0922187 and 0310217).

Technical Session VII (Thursday, October 10, 2019, 10:30 AM)
PHYTOPHYTE TOOTH DENTIN REVEALS NORIAN ARIDIFICATION PROCESSES INFLUENCED THE DIAGENETIC ENVIRONMENT OF THE CHINLE FORMATION
FORTNER, John D., Southern Methodist University, Dallas, TX, United States of America
The Upper Triassic (Norian; 228-208 Ma) Chinle Formation of Petrified Forest (PeFo) National Park was deposited during a time of major tectonic breakup and profound changes in atmospheric circulation and compositional Little has been done however to ask how this transition is related to breakup of the Late Triassic supercontinent Laurasia. Here we evaluate trends in the diagenetic environment of the Chinle Formation in western equatorial Pangea, and compare it to other regions of the world. Paleoenvironmental and sedimentary data from PeFo are consistent with other findings from the world. In the Chinle Formation of PeFo, Cement stratigraphy and up-section in the Morrison Formation of PeFo. Cement stratigraphy and up-section in the Morrison Formation of PeFo (e.g., cementation, microspar and carbonate; ambient water also recover temperatures between 13 to 17°C, too low for in vivo apatite synthesis. Together, these data suggest that Chinle phytosaur teeth record the signal of progressively evaporatively-enriched burial fluids, and that sucht palaeoecological trends influenced the geochemistry of the diagenetic environment.

Grant Information:
NSF Earth and Atmospheric Research 2NJT
Dallas Paleontological Society Frank Crane Memorial Scholarship
Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)
GEOGRAPHICAL SEGREGATION DUE TO ECOLOGICAL COMPETITION AMONG LATE JURASSIC DIPLODOCID S AURUPODS FROM THE MORRISON FORMATION (WESTERN U.S.A.)
FOSTER, John, Paleo Solutions, Inc., Vernal, UT, United States of America; TSCHOPP, Emanual, American Museum of Natural History, New York, NY, United States of America; NORELL, Mark, American Museum of Natural History, New York City, NY, United States of America; NORELL, Mark, American Museum of Natural History, New York City, NY, United States of America
North American diplodocid sauropods were historically subdivided into the slender Diplodocidae and the robust Apatosaurinae. However, recent systematic reassessments indicate that, within these respective subfamilies, two diplodocid lineages with robustly built limbs existed in the Upper Jurassic Morrison Formation. These are the Apatosaurinae (Apatosaurus and possibly Brontosaurus) and the diplodocine genus Galeamopus. To understand the ecological importance of this finding, we assessed the geographical and temporal ranges of these taxa, and combined these data with published information on taphonomy and sediments to create a world-spanning map of ecological relationships. We found that Diplodocidae and Apatosaurinae did not overlap in range, and that Diplodocidae were more geographically restricted. This pattern does not extend to the Late Jurassic Morrison Formation, where diplodocid sauropods were present in a variety of environments, from arid deserts to humid forests. Our results suggest that the ecological segregation observed in the Late Jurassic was driven by differences in habitat preferences, rather than competition for resources. This pattern may have persisted into the Cretaceous, and played a role in the radiation of sauropods across the world. Further research is needed to understand the ecological factors that drove the evolution and radiation of sauropods in the Late Jurassic.

Withdrawn

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than 750 reported apatosaursaur occurrences (isolated bones to articulated skeletons) resulting in a reduction of the confirmed geographical distribution of Apatosaurusine to southern Wyoming, Colorado, Utah, and Oklahoma (except for one partial skeleton with cervicals from northern Wyoming), whereas *Galeamopus* known mostly from northern Wyoming and Montana (with one occurrence in southern Wyoming). GM analysis confirmed that the two distinct lineages occupied largely overlapping morphospaces in the forelimb. The two taxa also overlap in occurrence in the same geological systems tracts, as well as in the same lithofacies. Taking the humeral shape as a proxy for locomotor strategy, and given the apparent temporal overlap of the two taxa, this distinct geographical distribution may be a result of both taxa being ecological competitors for a particular niche.

Our results add to a recently identified trend in geographical segregation among diplodocids, stegosaurs, and some other taxa, and show that we can test for such trends with a combination of phylogenetic and GM analyses, integrated with stratigraphic and lithologic data. Analyses at larger scale will need additional fieldwork and collection-based studies re-assessing the taxonomy of incomplete specimens from the Morrison Formation’s spatially and temporally less-explored areas.

**Grant Information:**

Theodore Roosevelt Memorial Fund and Division of Paleontology Postdoctoral Fellowship, American Museum of Natural History

**Technical Session XI (Friday, October 11, 2019, 9:00 AM)**

**BASELINE SHIFTS IN SMALL MAMMAL COMMUNITIES AT RANCHO LA BREA TRACK LATE QUATERNARY ENVIRONMENTAL CHANGES IN SOUTHERN CALIFORNIA**

FOX, Nathaniel, University of California Merced, Merced, CA, United States of America; SOUTHON, John, University of California Irvine, Irvine, CA, United States of America; TAKEUCHI, Gary, The La Brea Tar Pits and Museum, Los Angeles, CA, United States of America; FARRELL, Aisling, The La Brea Tar Pits and Museum, Los Angeles, CA, United States of America; FOX-DOBBS, Kena, University of Puget Sound, Tacoma, WA, United States of America; HILL, Tessa, University of California Davis, Davis, CA, United States of America; BLOIS, Jessica, University of California Merced, CA, United States of America; SOUTHON, John, University of California Irvine, Irvine, CA, United States of America; WORKSHOP PARTICIPANTS, Paleo to Policy Workshop, Tacoma, WA, United States of America

The extent of environmental change during the late Quaternary in the region around the Rancho La Brea (RLB) tar pits in Los Angeles, California has long been debated. Some studies suggest that environments have been relatively stable over the past 50,000 years while others suggest that local climates mirror regional patterns of increasing temperature and aridity through time. Here, we examine small mammal fossils from four RLB deposits (Project 23 (P23) Deposits 1, 7B, 13 and 14) spanning 50,000 to ~30,000 calibrated years before present and evaluate changes in their community composition, diet, and size through time. Such responses are good proxies for environmental change since small mammals are sensitive to habitat perturbations due to their small home ranges and limited mobility. We evaluate taxon-specific presence and abundance through time by comparing small mammal community composition between the P23 deposits and overall younger RLB Hancock Collection deposits that frequently yield post-glacial dates. Dietary niches are tracked in a subset of taxa via δ13C and δ15N stable isotope analysis of individually radiocarbon-dated fossils. Lastly, size changes are quan from metric and geometric morphometric measurements of some P23 taxa and their extant representatives. If past environments of Los Angeles were similar to present conditions, we hypothesize that 1) no directional change in species presence or abundance occurs through time or 2) that no directional change occurs in the osteologies (e.g., geographic, climatic, or dietary functional group affinity) of species that fluctuate in presence or abundance. Further, we expect no directional change to occur in intraspecific size or diet if local conditions remained stable. Results show similar sets of taxa among P23 deposits, though relative abundances vary: more mesic-adapted species generally become less abundant and more xeric-adapted and generalist species become more abundant through time. Compositional and functional differences also occur between P23 and Hancock deposits. Finally, δ13C, δ15N, and size shift through time in several species. These data indicate that the RLB community has shifted across the last glacial transition and that environmental changes, including aridity, seasonality, and/or vegetation changes, likely occurred.

**Grant Information:**

This project is supported by the National Science Foundation (EAR-1623852), the American Society of Mammalogists, and the Paleontology Society.

**A CALL TO ACTION AFTER THE PALEO TO POLICY WORKSHOP: HOW TO BUILD BRIDGES BETWEEN PALEONTOLOGICAL RESEARCH AND DECISION MAKING**

FOX-DOBBS, Kena, University of Puget Sound, Tacoma, WA, United States of America; HILL, Tessa, University of California Davis, Davis, CA, United States of America; IBARRA, Daniel, Stanford University, Stanford, CA, United States of America; OSTER, Jessica, Vanderbilt University, Nashville, TN, United States of America; WORKSHOP PARTICIPANTS, Paleo to Policy, Tacoma, WA, United States of America

The Paleo to Policy: Building bridges between paleoclimate research and decision making workshop (February, 2019) brought together a diverse group of paleo scientists, with the following set of objectives: 1) explore best practices and highlight excellent examples of paleoclimate/paleoecology research relevant to decision making, 2) build communication skills in participants specifically for working with policymakers, managers, and conservation groups, 3) provide the foundation for co-creation of ideas for research with scientists, conservation experts, managers, and policymakers, and 4) build a network of researchers across career stages that are committed to the societal relevance of their work and continuing to work together on these goals.

The Paleo to Policy working group now aims to share the resources and ideas produced by the workshop with a range of paleoscience communities, and is focused on the key challenge of empowering paleontologists to connect and communicate with policy decision makers. In this presentation we will discuss best practices for incorporating paleoclimate/paleoecology work into decision making, including identifying policy claims and understanding the role of values, beliefs and attitudes. We will then highlight broad skills of paleoclimate researchers and successful examples of paleo work being incorporated into the decision-making process. Successful examples provide models for how paleontology research can influence, and potentially shape, policy.

There are clear examples from conservation paleobiology and paleoclimatology to demonstrate how these fields are relevant to policy and decision-making. We suggest that the entire field of paleontology has strong potential for engaging stakeholders, both in terms of communicating the policy relevance of research findings and making intentional connections to policy makers during the design and implementation of projects. While some areas of vertebrate paleontology may have more obvious links to policy (i.e., Quaternary mammalian records used to inform species listing and land management), connecting all areas of vertebrate paleontology (across the spectra of temporal and taxonomic categories) is important work that will require creative development and implementation.

**Grant Information:**

The Paleo to Policy workshop was funded by a NSF CAREER award to T. Hill (OCE 144451).

**Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)**

**DOCUMENTING AN ECOLOGICAL REPLACEMENT EVENT FROM THE MIOCENE ON AN ECOLOGICAL TIMESCALE**

FRANK, Tanner M., University of California, Berkeley, Berkeley, CA, United States of America; BELL, Michael A., Berkeley, CA, United States of America

Invasive species are generally recognized as a threat to global biodiversity, with anthropogenically introduced taxa causing local extinctions of native species in ecosystems around the world. It is important to understand the dynamics of ecological replacement in scenarios without human influence in order to form a baseline against which to compare anthropogenic invasions, but the pervasiveness of human impacts globally and the difficulty of conducting long-term monitoring before an invasion takes place makes this impractical to approach with neontological studies. While the fossil record has many examples of community composition changing through time, there are few documented cases where species invasion can be correlated with local extinction. Varved diatomite beds located in a quarry near Fernley, Nevada provide an example of such an ecological replacement event in lacustrine fish during the Late Miocene (Truckee Formation), which is documented at a nearly annual temporal resolution. Fossil sticklebacks (*Gasterosteus dorsatus*) are found ubiquitously throughout the majority of the section, but in the uppermost section exposed in the quarry the dominant species abruptly transitions to killifish (*Fundulus nevadensis*). Changing diatom composition through the section suggests that the fossils were deposited in a small, isolated body of water which later became connected to a larger regional system of lakes, implying a potential environmental mechanism for the replacement of...
sticklebacks with killifish. Based on their occurrence data, killifish and sticklebacks are trapped in the lake for a period of around 300 years per generation and below which the non-dominant species is virtually absent. This interval of time puts the transition at close to an order of magnitude slower than most reported modern ecological replacement events, although it has a similar outcome. Measurements of fish size and morphology have implications for competition occurring between the two taxa. These findings suggest that modern species invasions may be accelerated, but fundamentally similar to those in the past, and underscores the utility of palaeontological studies with high temporal resolution for contextualizing modern ecological change.

Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)

TAXONOMIC IMPLICATIONS OF MEASUREMENT INDICES OF THE IDENTIFICATION OF ISOLATED SAUROPOD TEETH

FRAUENFELDER, Timothy, University of New England, Armidale, Australia; CAMPIONE, Nicolas E., University of New England, Armidale, Australia; BELL, Phil, University of New England, Armidale, Australia

Slenderness and Compression indices (SI and CI, respectively) are commonly used to categorize sauropod teeth. The SI distinguishes broad-crowned (e.g., Camarasaurus, Brachiosaurus; SI<4) from narrow-crowned taxa (e.g., diplodocids, Titanosaurus; SI>4), whereas the CI has been used sparingly to separate isolated titanosaurian teeth based on labiolingual compression. Whilst the indices likely reflect an aspect of tooth function, they are generally used for broad taxonomic purposes. However, the measurements used to generate these ratios (tooth height, length and width) have yet to be explored within an allometric framework. Here we use line-fitting bivariate statistics to test the taxonomic utility of these indices based on an extensive dataset of sauropod tooth measurements (N=705). Overall differential scaling between tooth height and length (SI measurements) is recovered between sauropod groups (p<0.001), including notable separation between the broad- and narrow-crowned sauropods. As expected, both diplodocids and titanosaurians have the narrowest teeth of all groups. However, whilst these two groups do not differ in SI values, they differ in scaling of both slope and elevation. Differential scaling between taxonomic units is also recovered when comparing tooth width and length (CI measurements; p<0.001). Therefore, our results generally support the use of these indices for interpreting broad taxonomic levels. Some caution, however, is warranted. Indices do not consider body size, ontogeny, or positional variation within the jaw and, in particular, they assume that slope coefficients between groups are consistent. Our results reject this assumption in certain groups. For instance, tooth height is positively allometric relative to its length in diplodocids and camarasauromorphs compared to the more isometric patterns noted in most other groups. This means that, among certain groups, index values will vary with size. Considerations of scaling are especially important for intermediate teeth that fit neither the typical ‘broad’ vs. ‘narrow’ categories. From an evolutionary perspective, bivariate plots indicate that early groups of sauropods (e.g., Plateosaurus) were relatively constrained in terms of their morphospace. In comparison, later forms, such as diplodocids and titanosaurians, explored more extreme regions of morphospace. Our study reveals the importance of understanding measurement data within an allometric framework, which can be extended to understand evolutionary processes.

Grant Information:
This project was funded by the University of New England.

Technical Session XV (Saturday, October 12, 2019, 11:45 AM)

RATES OF MORPHOLOGICAL EVOLUTION IN ANOMODONTIA (THERISPIDA) ACROSS THE END-PERMIAN MASS EXTINCTION

FRÖBISCH, Jörg, Museum für Naturkunde, Berlin, Germany; JELEN, Veronika, Humboldt-Universität zu Berlin, Berlin, Germany; BROCKLEHURST, Neil, University of Oxford, Oxford, United Kingdom

Anomodonts were the most speciose Permian-Triassic therapsid clade and had an impressive morphological and ecological diversity. They obtained a cosmopolitan distribution and became the dominant herbivores of their time. However, they were severely affected by the end-Permian mass extinction, experiencing a massive bottleneck in their taxonomic diversity. In contrast, anomodont disparity reached an early peak in the mid Permian and declined continuously throughout the evolutionary history of the clade, being little affected by the end-Permain event. For the purpose of this study we investigated rates of change of discrete morphological characters throughout the anomodont’s evolutionary history and across the end-Permian mass extinction. Based on a recent phylogenetic data set and up-to-date stratigraphic ranges, node and branch rates of morphological evolution were calculated to identify whether a clade, branch or time period had a significantly high, low, or moderate change rate. We found a large age range, and below which the non-dominant species is virtually absent. This interval of time puts the transition at close to an order of magnitude slower than most reported modern ecological replacement events, although it has a similar outcome. Measurements of fish size and morphology have implications for competition occurring between the two taxa. These findings suggest that modern species invasions may be accelerated, but fundamentally similar to those in the past, and underscores the utility of palaeontological studies with high temporal resolution for contextualizing modern ecological change.

Grant Information:
This research was funded by the German Research Foundation (DFG).

Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)

MORPHOLOGY AND NEUROVASCULAR ANATOMY OF A TITANOSAUR SAUROPOD OSTEODERM FROM THE UPPER CRETACEOUS OF BIG BEND NATIONAL PARK, TEXAS

FRONIMOS, John A., Vassar College, Poughkeepsie, NY, United States of America

Osteoderms are among the most distinctive attributes of the Lystrosoria, a speciose clade of Cretaceous titanosaur sauropods, yet the function of the osteoderms remains uncertain. Hollow spaces inside some osteoderms have been used to suggest a function as mineral storage sites, accessed during times of environmental stress or egg-laying. Subsequently, varying stages in the development of internal hollows have been reported from other osteoderms. A new specimen (TMM 45888) from the Upper Cretaceous Javelina Formation of Big Bend National Park, Texas, provides additional insight into the diversity of internal structure among lystrosorh osteoderms. Found in isolation, TMM 45888 can presently only be referred to Lystrosoria incertae sedis. It exhibits an ellipsoidal morphology with a low bulb lacking a cingulum. The surface is ornamented with ridges and grooves radiating outwards from its long axis. Although this has allowed oviraptorid reproduction to be relatively well understood, few studies have explored other aspects of their biology—a problem even more true of other oviraptorosaurs. Regardless, their phylogenetic position close to Aves and the abundance of fossil material makes oviraptorosaurs ideal organisms for understanding the ancestral conditions of modern birds.

Romer Prize Session (Thursday, October 10, 2019, 9:00 AM)

GROWTH AND BEHAVIOUR IN OVIRAPTOROSAURS

FUNSTON, Gregory F., University of Alberta, Edmonton, AB, Canada

Oviraptorosaurs were feathered theropod dinosaurs from the Cretaceous (145–66 Ma) of Asia and North America. They are typically divided into four clades: the basal cauropithecoidea and avimimids, and the more derived caenagnathids and oviraptorids. Of these, oviraptorids are the best known, represented by dozens of complete skeletons, some associated with clutches of eggs. Although this has allowed oviraptorid reproduction to be relatively well understood, few studies have explored other aspects of their biology—a problem even more true of other oviraptorosaurs. Here, I capitalize on this opportunity by systematically examining two important, understudied aspects of oviraptorosaur biology: growth and gregarious behaviour. Growth is examined via osteohistology, using ontogenetic series from representatives of avimimids, caenagnathids, and oviraptorids. Gregarious behaviour is revealed through spectacular new fossil discoveries that elucidate the population structure and specific behaviours of flocks of oviraptorosaurs. To understand the evolution of these traits, oviraptorosaur phylogeny is comprehensively revised, using new specimens.
to clarify the taxonomy of problematic species and updated character scoring to improve phylogenetic resolution. The results show disparate patterns in the growth and gregariousness of oviraptorosaurs. Whereas basal oviraptorosaurs had stunted growth limiting to clarify the taxonomy of problematic species and updated character scoring a strong phylogenetic signal, suggesting two independent origins within oviraptorosaurs. Evidence of huddling behaviour in an oviraptorid suggests relatively advanced sociality and provides a thermoregulatory mechanism for the origin of sociality in birds. These findings greatly improve our knowledge of oviraptorosaurs and suggest that they may have converged on birdlike biology more than previously recognized.

Grant Information: Yanier Canas, Natural Sciences and Engineering Research Council of Canada, the University of Alberta, and Alberta Innovates provided funding to G.F.F.

Technical Session XI (Friday, October 11, 2019, 9:30 AM) MAMMALIAN RESPONSES TO LATE QUATERNARY ENVIRONMENTAL CHANGE IN EASTERN AUSTRALIA.

FUSCO, Diana A., Flinders University, Bedford Park, Australia; THORN, Kyle M., Flinders University, Bedford Park, Australia; SHUTE, Ellen R., Flinders University, Bedford Park, Australia; TYLER, Michael J., University of Adelaide, Adelaide, Australia; GIBBS, Nimue R., Flinders University, Bedford Park, Australia; ARNOLD, Lee J., University of Adelaide, Adelaide, Australia; SNIDERMAN, J.M. Kale, University of Melbourne, Parkville, Australia; WORTHY, Trevor H., Flinders University, Bedford Park, Australia; PRIDEAUX, Gavin J., Flinders University, Bedford Park, Australia

Characterizing the longer-term impacts of climatic shifts and human activities on species is among the most vital insights that paleontology can offer, providing benchmarks for calibrating modern and projected future ecological change. However, its potential in this respect has been markedly underutilized, especially in Australia. To date, only a few studies have sought to track paleoecological change in Australian vertebrates over the relatively recent geological past, with most focused in southern Australia. Here we investigate changes in mammalian species composition and relative abundances through a 5.3-million-year interval leading up to human arrival on the continent and the final phase of megalafaunal extinctions. The Cuddie Springs site in Western New South Wales contains a faunal assemblage from the late Pleistocene in Australia. Variations in assemblage composition and relative-abundance trajectories of small-mammal species align with vegetation shifts inferred from co-occurring fossil pollen, and to a greater climate in early in MIS 3. Thus, cathedral Cave preserves the only diverse vertebrate and pollen assemblages known from Australia that accumulated across the 30,000-year interval leading up to human arrival on the continent and the final phase of megalafaunal extinctions.

Grant Information: Australian Research Council Discovery grant to G J Prideaux (DP150100264) Maxim Foundation Royal Society of South Aust Australian Nuclear Science & Technology Organisation

Regular Poster Session I (Wednesday, October 9, 2019, 4:15 - 6:15 PM) FIRST RECORDS OF THE SAWFISHES PRISTIS (LINNÉ, 1799) AND ANOXYPRISTIS (WHITE AND MOY-THOMAS, 1941) FROM THE Oligocene of North and South Carolina, U.S.A.

GALE, Ashby W., Charleston Fossil Adventures, LLC, Charleston, SC, United States of America

Sawfishes are reported from Cenozoic marine deposits across the southeast, and are known primarily from their rostral denticles, teeth, rostra, and centra. Denticles and partial rostra are reported from the Eocene of the Gulf and Atlantic Coastal Plain and the Mio-Pliocene of the Atlantic Coastal Plain, leaving a published gap during the Oligocene, unrepresentative of the lineage. Rostral denticles referred to the sawfish Pristis sp. are described here from the upper Oligocene (Chattian) Chandler Bridge Formation in Ladson, Berkeley County, South Carolina. A partial rostrum referred to Anoxypristis sp. is described from the lower Oligocene (Rupelian) Ashley Formation in Summerville, Dorchester County, South Carolina. Further specimens include Anoxypristis sp. and rostral denticles from John’s Island, Charleston County, South Carolina. Records from North Carolina include 12 isolated Anoxypristis rostral denticles surface collected from Oligocene dredge spoils in the Belgrade Quarry, Jones County, North Carolina. These occurrences are the first publicly accessible records of Pristidae from Oligocene deposits of the Atlantic Coastal Plain, indicating the continuous Cenozoic existence of Pristidae from the Eocene.

Colbert Prize Poster Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM) EXPLORING THE OLFACtORY CAPABILITIES OF ANt-EATING MAMMALS USING THE CRIBRIFORM PLATE AS AN OSTEoLOGICAL PROXY

GARLAND, Kathleen L., Montpellier University, Montpellier, France; HAUTIER, Lionel, Montpellier University, Montpellier, France; FERREIRA-CARDoso, Sergio, Montpellier University, Montpellier, France; WRIGHT, Mark, Harvard University, Cambridge, MA, United States of America; MARTINEZ, Quentin, Montpellier University, Montpellier, France; FABRe, Pierre-Henri, Montpellier University, Montpellier, France; LEBRUN, Renaud, Montpellier University, Montpellier, France; DELSUC, Frédéric, Montpellier University, Montpellier, France

All myrmecophagous (ant-and termite-eating) mammals possess convergently evolved feeding morphologies, specialised for their strict diet. It is unknown, however, if these morphological convergences reflect similarities in their ability to detect ants/termites. All myrmecophagous species have been found to share similar sniffing behaviours when foraging, suggesting a specialisation to detect ant/termite chemical odours. Cribiform plate (CP) morphology metrics (surface area and foramina number) have been previously used to reliably predict the number of functional olfactory receptor genes in mammalian species, which is directly linked to their olfactory capabilities. Consequently, the CP has been suggested to be an osteological proxy for predicting the olfactory capacities in living and extinct mammals. Likewise, the surface area and complexity of turbinal bones in the snout has been related to olfactory capabilities. Here, we used X-ray micro-computed tomography to compare the CP and turbinal morphologies of nine myrmecophagous species and their sister taxa. The CP and olfactory turbinal morphologies of the giant armadillo (Priodontes maximus) and the aardvark (Orycteropus afer) were shown to be highly convergent, which might be related to their unique fossorial behaviour. Otherwise, no clear pattern of convergence was detected among myrmecophagous mammals. Using generalized least squares analyses, we found that CP and olfactory turbinal surface area were strongly correlated, suggesting strong developmental, and underlying functional, integration patterns in the rostrum.

Grant Information: Funded by the European Research Council consolidator grant, the Centre National de la Recherche Scientifique and the Erasmus Mundus Master Programme in Evolutionary Biology. Symposium: Quaternary Extinctions (Friday, October 11, 2019, 3:45 PM) PREDATORS AND PREY FROM THE MIDDLE PLEISTOCENE RECORD AT CUDDIE SPRINGS

GARVEY, Jillian, Dr, Melbourne, Australia; FIELD, Judith, UNSW, Sydney, Australia

The Cuddie Springs site in Western New South Wales contains a faunal sequence dates to c.900,000 years. While renowned internationally for its human-megafauna sequence between c 40-30ka, Cuddie Springs also documents the most southern appearance of Quinkana sp., Palimnarchus sp. and Crocodylus sp. The former two species have been identified as the primary agents in the accumulation of a range of megafauna in a discrete horizon dated between 350-600 (mean. 400 ka) by ESR dating. The excellent preservation of the skeletal material and microscopic pollen has allowed a reconstitution of the local vegetation and associated faunal assemblages. South west ephemeral waterhole, predator crocodiles and a marsupial megafauna occur together in a warmer and wetter environment, providing a unique picture of middle Pleistocene Australia. Cuddie Springs is one of the few sequences in an open setting from semi-arid/ard Australia and provides important insights to the rich prehistory of the Australian continent.
Regular Poster Session III (Friday, October 11, 2019, 4:15 - 6:15 PM)

REDIAGNOSIS OF PARASAUROLOPHUS CYRTOCRISTATUS BASED ON THE ADDITION OF NEW MATERIAL FROM THE FRUITLAND FORMATION, NORTHERN NEW MEXICO

GATES, Terry A., North Carolina State University, Raleigh, NC, United States of America; SERTICH, Joseph, Denver Museum of Nature & Science, Denver, CO, United States of America

Of all hadrosaurid ornithopod dinosaurs, the genus Parasaurolophus may be the most distinctive, with the three recognized species possessing a hollow, tube-shaped crest extending posterodorsally beyond the skull roof. Unique features of crest shape have provided the bulk of characteristics used in specific diagnoses, largely ignoring other features of the skull. This practice is problematic because the holotype specimen of P. cyrtocristatus (FMNH P-279393) includes a cranium with only a partial premaxilla, partial skull roof and braincase, and a complete, uniquely shaped curving crest that forms the basis of its diagnosis. For over 55 years, this specimen had been the only with a hypercurved crest until abundant, new Parasaurolophus specimens from Utah revealed that crest curvature is an ontogenetic artifact, bringing into question the validity of P. cyrtocristatus on the basis of that feature alone. A new partial subadult skull (DMMN EVP.132300) collected from the Fossil Forest Member of the Fruitland Formation demonstrates that P. cyrtocristatus can be diagnosed by at least four cranial, non-crest characteristics in addition to at least two crest-related traits independent of crest curvature. These traits are: straight preorbital premaxillae; dorsally raised squamosals on posterior margin; emargination between squamosal and supratemporal notch; between pre- and post-cotyloid processes; common median chamber elongate and equal to narial tracts in size; and unique shape of the terminal lateral premaxillary process. A phylogenetic tree produced from a recently published matrix with the addition of six new characters produced a strict consensus tree that unites P. cyrtocristatus with P. tubicen. This hypothesized arrangement makes intuitive sense considering that both species occur in close geographic proximity in successive formations temporally separated by only ~1.5 million years. Yet, this study is the first to produce such an evolutionary hypothesis because crest shape and length have been the major character traits used in phylogenetic studies, consistently placing the two 'long-crested' species, P. tubicen and P. walkeri, together. Future work will use the diagnostic information of Parasaurolophus species to identify the taxon found in the Kaiparowits Formation of Utah, based on a series of skulls and postcranial material.

Technical Session II (Wednesday, October 9, 2019, 9:00 AM)

CT IMAGING OF DINOSAUR FOOTPRINTS: HIDDEN TOPOGRAPHY AND THE ORIGIN OF PENETRATIVE TRACK DIVERSITY

GATESY, Stephen M., Brown University, Providence, RI, United States of America; TURNER, Morgan L., Brown University, Providence, RI, United States of America; FALKINGHAM, Peter L., Liverpool John Moores University, Liverpool, United Kingdom

Dinosaur footprints are trace fossils documenting the interaction of live animals with deformable ground. Although some tracks are relatively accurate molds of the foot, most are not. Factors such as substrate consistency and foot motion are known to give rise to disparate track morphologies that may differ considerably from static pedal anatomy. Although typically viewed as surfaces, any given track is a sample of a broader, typically hidden, volumetric phenomenon. On relatively soft substrates, dinosaur tracks sink deeply. Such penetrative tracks preserve evidence of track formation and withdrawal (as depressed and elevated features) through multiple layers. But how closely do the visible surfaces of exposed slabs reflect the actual, underlying topography? We used CT imaging to reconstruct internal surfaces of penetrative tracks from the Early Jurassic (~200 MYA) of the Connecticut Valley. Our first glimpse inside these fossil slabs confirms that natural breaks, mechanical splitting, and subsequent preparation have significantly damaged most exposed surfaces. In particular, delicate elevated features documenting foot withdrawal were either too fragile to survive slab separation or were mistakenly removed. Such topographic structures are key to understanding how deep tracks formed and to explaining the origin of Connecticut Valley footprint disparity. CT data enable us to more clearly observe the results of foot-sediment interactions than is possible from exposed surfaces alone, and serve as key constraints on reconstructions of extant dinosaur limb kinematics.

Grant Information:
U.S. National Science Foundation grants EAR-1452119 (S.M.G. and P.L.F.) and a Brown University Salomon Faculty Research Award (S.M.G.)

Technical Session II (Wednesday, October 9, 2019, 12:00 PM)

A SUPERFOOD FOR MESOZOIC HERBIVORES? EMERGING DATA ON THE EXTREME DIGESTIBILITY OF EQUISETUM AND IMPLICATIONS FOR YOUNG, GROWING HERBIVOROUS SAUROPODS

GEE, Carole T., University of Bonn, Bonn, Germany; HOWELL, Mariath M., University of Bonn, Bonn, Germany; BÖTTGER, Christian, University of Bonn, Bonn, Germany; SÜDEKUM, Karl-Heinz, University of Bonn, Bonn, Germany

Although the notion of a super nutritious 'power bar' for the herbivorous dinosaurs has been scoffed at, it has been documented through an extensive series of laboratory experiments that many of the nearest living relatives of the Jurassic flora would have been very good sources of nutrition for Mesozoic herbivores. Based on fermentation experiments using a well-established feed evaluation test for livestock, among the best sources of energy would have been the gymnospermous leaves of Araucaria, Ginkgo, and the pinaceous conifers. Yet, there is another plant group that surpasses all other plant groups, even forage grass, in regard to nutritional quality—Equisetum. Here we present new data on the energy yield of several species of horsetail as evaluated by the Hohenheim Gas Test. Altogether, seven samples of Equisetum spp. were tested in vitro experiments in the laboratory and comparative analysis. In all trials on its digestibility for herbivores, Equisetum consistently released more energy than all other plant groups, exceeding the average amount of calories released by 16 species of grass. The energy release of Equisetum is rapid from the onset, and its fermentation curve remains high throughout the course of 72 hours. Furthermore, nutritional analysis shows that horsetails also provide high quantities of protein and mineral nutrition, both of which are essential for growth. Morphologically, the genus Equisetum has remained virtually unchanged since the Jurassic. Assuming that living Equisetum and its ancient relatives had a similar physiology and thus nutritional qualities, the small-stature, ground-dwelling, colony-forming stands of Mesozoic horsetails along rivers and around lakes and ponds would have offered herbivores, especially hatchlings and young herbivorous dinosaurs, a plentiful, accessible, and extremely nutritious source of food. Comparisons to the dietary preferences of modern wild fowl that depend on Equisetum spp. as a "superfood" during brooding and the early stages of life will be discussed, as well as the food ecology and behavior adaptations of living herbivorous reptiles.

Preparers' Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)

HIGH RESOLUTION REMOTE SENSING APPLIED TO FOSSIL DISCOVERY: OVERVIEW AND PROSPECTS

GHEZZO, Elena, University of Venice/University of Oregon, Eugene, OR, United States of America; MASSIRONI, Matteo, University of Padova, Padova, Italy; DAVIS, Edward B., University of California Berkeley, Eugene, OR, United States of America

We have analyzed the physical properties of fossils in museum collections and compared them to the regional-scale information recorded by optical sensors (RGB and multispectral cameras) gathered from satellites, drones, weather balloons, and kites. Such an approach allows researchers to record visual details of fossils in the original context of deposition in the field and, more importantly, to determine the position of uncollected specimens still exposed at the ground surface in areas that are difficult to access. When a fossil exposed on the ground is captured by a camera, it records information related to the color and physical properties of the specimen in accordance with the sensitivity of the used sensor. Therefore, the possibility of discerning it from the depositional matrix is related to the other information transmitted by the rest of the image.

Keeping in mind these limitations, we introduce the principal concepts of Remote Sensing applied to paleontology with insights of the methodologies and spatial algorithms we have used. In particular, we discuss the spectral signatures of fossils, their recalibration for multispectral and visible bands, and their application to imagery of specific paleontological collecting areas including the Pisco Basin and the John Day Fossil Beds. We have statistically evaluated spatial maps of probabilities to assess whether the spectral signature of specific fossils analyzed in the lab match with the information in the pixels of the remote sensing images.

This method is applicable to any kind of fossils, from large tetrapods to vegetation, allows researchers to exactly locate fossils in advance of fieldwork, so we expect it to become a significant step forward in the approach to fieldwork, for monitoring paleontological resources, and to increase the fossil record available for future paleontological studies.
New Zealand is a key area for understanding the ancient history of penguins (Order Sphenisciformes). Fossils from New Zealand range in age from Paleocene up to Pleistocene, constituting a sampling period that spans more than 60 million years. The New Zealand fossil record includes many ‘giant’ penguin species (i.e., larger than living penguins) which may have represented the most complete pre-Pleistocene vertebrate reported from this region. The fossil was found also in Antarctica, South America and Australia. These taxa are found also in Antarctica, South America and Australia. These traits hint at differences in locomotion and foraging when compared with living species, although most body plans for ancient penguins are inferred from largely incomplete skeletons. Here we describe a mostly-complete giant-sized penguin with many bones articulated in life position. The fossil was found in an Oligocene sqly mudstone from the North Island of New Zealand and currently represents the most complete pre-Pleistocene vertebrate reported from this region. The specimen shares several morphological features with the New Zealand-endemic taxon Kairuku and in preliminary phylogenetic analyses the new fossil forms a clade with this genus. Furthermore, the forelimb elements of Kairuku grebneffi, a similarly-aged giant penguin from the South Island of New Zealand, are almost identical in size when compared with the North Island specimen. The hindlimbs elements of the North Island fossil are significantly longer, exceeding in length all previously described specimens of Kairuku. Moreover, the specimen presents a mixture of characters that show a transitional state between the ancestral body plan found in other Oceano-Oligocene giant penguins and the apomorphic body plan found in Kairuku, providing insight into the diversification of ‘giant’ penguins.

Grant Information:
Massey University Doctoral Scholarship

Regular Poster Session III (Friday, October 11, 2019, 4:15 - 6:15 PM)
A DIVERSE MIOCENE TOOTHED WHALE (ODONTOCETI) FAUNA FROM CALVERT CLIFFS, ATLANTIC COASTAL PLAIN, U.S.A.

GODFREY, Stephen, Calvert Marine Museum, Solomons, MD, United States of America; LAMBERT, Olivier, Institut royal des Sciences naturelles de Belgique, Bruxelles, Belgium

A diverse odontocete fauna of 29 extinct species is known from along Calvert Cliffs, Maryland, U.S.A. and other Miocene-age outcrops within the Chesapeake Bay region (comprising the Calvert, Choptank, and St. Marys formations). Squalodontidae is represented by three species, Squalodon calvertensis, S. whitmorei, and a new species intermediate in size between the two aforementioned forms. Physeteroidea includes the physeterids Autophyseter mediatlanticus and Ornychocetous crocodilus, and an unnamed taxon with macroraptorial teeth. Ziphiidae includes two unnamed species; cf. Mesopiliceps sp. and Ziphidae incertae sedis. Squalodelphinidae is known by two species: Phocagenius venatus and Notosetus sp., and Platanistidae by four species: Aroeadelphis natator, Zarhachis flagellator, Pomotadophis inaequalis, and a new species. Euphradophinidae features prominently with at least four species; Xiphiusus bosii, X. cristatus, Schizodelphis barnesi, and S. morkhoveni. Early delphinids are the most diverse, including Delphinodon dividum, Kentrodon pertus, and Phipadophis cornutus, Lophocetus calvertensis, and at least three new species. Finally, Pontoporiidae is represented by Stenodelphis russelii. Four of these families have living representatives: Physeteroidea (sperm whales), Ziphidae (beaked whales), Platanistidae (Ganges river dolphin), and Pontoporiidae (La Plata dolphin). The long and slender-headed extant delphinids are the most common odontocetes along Calvert Cliffs, squalodontids the most archaic, and physeterooids the largest. Squalodelphinids, ziphids, and pontoporidae are known only from a few incomplete skulls, so much remains to be learned from future discoveries and the reassessment of collection specimens.

In terms of its taxonomic diversity and number of specimens, this fauna rivals the Neogene odontocete faunas in Peru, Antwerp basin (Belgium), Belluno (Italy), Mexico, and elsewhere in the United States (Lee Creek Mine in North Carolina, Florida, Shark Tooth Hill in California, and Pollack Farm site in Delaware). As for their stratigraphic distribution, these odontocetes range in age from the Aquitanian through to the Tortonian, with the large majority occurring within the Aquitanian and Langhian, the latter being the most species rich. The two faunas encompass the Mid Miocene Climatic Optimum (MMCO), a time (ca. 16-14 Ma) when average global temperatures may have been ca. 3° C warmer than today.

Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM)
A NEW DREPANOSAURUROMORPH FROM THE CHINLE FORMATION OF PETRIFIED FOREST NATIONAL PARK, ARIZONA

GONCALVES, Gabriel S., University of Washington, Seattle, WA, United States of America; SIDOR, Christian A., University of Washington, Seattle, WA, United States of America

Drepansaururomorph is an extinct group of basal diapsid reptiles known from the Middle to Late Triassic (237–212 MA). The clade currently includes seven genera (Avricerum, Dolabrourus, Drepansaurus, Hypuronecor, Kyrgyzsaurus, Megalansaurus and Vallesaurus) that are known from fossils collected in Europe (Italy, U.K.), North America (Arizona, New Mexico, New Jersey), and Asia (Kyrgyzstan). The first described drepansaururomorph, Drepansaurus unguicaudatus, was based on a flattened holotype preserving...
most of a complete skeleton. Here, we describe a new drepanosauromorph species from the Chinle Formation in Petrified Forest National Park, Arizona, based on a three-dimensionally preserved ungual phalanx of the second digit of the hand. One characteristic that distinguishes this claw is its size. The proximodistal length of the manual ungual phalanges of most drepanosauromorphs (except *Drepanosaurus*) fall within a range from about 0.125 cm to 1 cm. Measuring from the dorsal edge of the cotyle to the distal apex of the phalanx, the specimen is 2.23 cm in length, whereas the corresponding ungual from the holotype of *Drepanosaurus unicolor* is 2.38 cm, and the right second manual ungual from Hayden Quarry *Drepanosaurus* is 2.07 cm in length. In addition, the Petrified Forest specimen differs significantly from all known *Drepanosaurus* specimens because of the shortened dorsoventral height of the claw, a lack of compression along the pre-axial/post-axial plane, and the overall morphology of the specimen. Its ventral margin starts to recurve at around 1 cm from the proximal end of the specimen, near the proximal margin of the lateral tuberosities, and around 1.2 cm on the dorsal margin. This contrasts with the narrow, more linear, digit preserved in other specimens. The more robust proximal end of the specimen, near the proximal margin of the lateral tuberosities, and around 1.2 cm on the dorsal margin. This contrasts with the narrow, more linear, digit preserved in other specimens.

Technical Session XVIII (Saturday, October 12, 2019, 4:00 PM)

**DIET AND ECOLOGY OF TWO LOPHIALETIDS FROM THE EOCENE OF ERLIAN BASIN, CHINA: COMBINED EVIDENCE FROM MESOWEAR AND STABLE ISOTOPE ANALYSES**

GONG, Yanxin, IVPP, Chinese Academy of Sciences, Beijing, China; WANG, Haibing, IVPP, Chinese Academy of Sciences, Beijing, China; WANG, Yuan-Qing, IVPP, Chinese Academy of Sciences, Beijing, China; BAI, Bin, IVPP, Chinese Academy of Sciences, Beijing, China; WANG, Hailing, IVPP, Chinese Academy of Sciences, Beijing, China

Lophialetidae are endemic Asian tapiroids that were widely distributed in Asia during the Eocene. The two extinct lophialetids, *Schlosseria magister* and *Lophialetes expeditus* are the most abundant species in this family. However, their dietary and ecological characteristics have been largely unknown to date. In this study, we reconstructed for the first time the paleoecology of these two lophialetids using mesowear and stable carbon isotope analyses of fossil teeth excavated from the Huheboerhe area of the Eocene of Erlian Basin, Inner Mongolia, China. The mesowear analyses suggest that the diets of *S. magister* and *L. expeditus* changed from browsers, browse-dominated mixed feeders, mixed feeders, to grazers in the area from ~52 to ~42 Ma. It means that the dietary structure of *S. magister* and *L. expeditus* varied from less abrasive diets to more abrasive diets through time. The stable carbon isotope analyses suggest that both *S. magister* and *L. expeditus* had pure C3 diets and inhabited an environment dominated by C3 vegetation. The diets in diets and habitat of *S. magister* and *L. expeditus* were likely related to global climate change in that time period. The gradual drop of the global temperature as revealed by the marine oxygen isotope records after the Early Eocene Climatic Optimum led to a drier and more open terrestrial ecosystem in the Huheboerhe area in the Erlian Basin, probably resulting in gradual changes in floral composition of the forest environment inhabited by *S. magister* and *L. expeditus* through time. Hence, herbivores highly susceptible to vegetation modification had to develop new resource exploitation strategies to adapt to the changes. *S. magister*, ultimately, which are considered as the direct ancestor of *L. expeditus* and having low level of ecological flexibility, were unable to adapt to the drastic changes in habitat and became extinct at ~45 Ma.

Grant Information:
The research was funded by the National Natural Science Foundation of China (41572021 and 41672014) and US National Science Foundation (DMM-1644779).

Technical Session II (Wednesday, October 9, 2019, 9:45 AM)

**TITANOSAURIAN SAUROPOD DINOSAUR FOSSILS FROM THE UPPER CRETACEOUS LAPUR SANDSTONE (TURKANA GRITS), TURKANA BASIN, NORTHWESTERN KENYA**

GORSCKA, Eric, Midwestern University, Downers Grove, IL, United States of America; SERTICH, Joseph, Denver Museum of Nature & Science, Denver, CO, United States of America; MANTHI, Fredrick K., National Museums of Kenya, Nairobi, Kenya

Exploratory efforts in sparse Upper Cretaceous African deposits have yielded only a handful of dinosaurian specimens, largely based on solitary occurrences. Although elusive, several diagnostic African dinosaur species have only recently augmented our understanding of the scarce Late Cretaceous African fossil record relative to better-known coeval deposits elsewhere. Thus far, titanosaurian sauropod dinosaurs have been used to establish initial paleobiogeographical perspectives on the Late Cretaceous of Africa as congruent patterns with other vertebrate clades await further description and testing. *Mansourasaurus shahinae* from the Campanian of Egypt demonstrates affinities with titanosaurians from Eurasia, whereas *Rukwatitan bisepultus* and *Shingopana songwensis* from the Turonian–Campanian of Tanzania share affinities with taxa from Gondwana suggesting a coarse latitudinal division in Late Cretaceous African faunas. However, questions remain regarding the extent of these early, yet encouraging, interpretations for Late Cretaceous African dinosaur faunas. Exploratory reconnaissance of the lower beds of the Late Cretaceous (‘Maastrichtian’) Lapur Sandstone (“Turkana Grits”) of northwestern Kenya has recovered fossil remains of a diverse terrestrial fauna, including turtles, crocodyliiforms, and abelisaurid theropod and ornithopod dinosaurs. Due to the coarse depositional environment of the sandstones, titanosaurians represent the most abundant fossils encountered, including the associated skeleton of a small individual, KNM-WT 65086, and various isolated postcranial remains that allude to a diverse sauropod fauna. KNM-WT 65086 is represented by fragments of cervical, sacral, and caudal vertebrae; a partial scapulocoracoid; fragments of the forelimb and hindlimb; and an osteoderm. Uniquely features of KNM-WT 65086 include a midline ridge along the base of the neural canal and a protuberance on the posterior surface of the neural arch pedicle in several caudal vertebrae. Tip-dated phylogenetic analysis tentatively places KNM-WT 65086 outside of Saltasauridae among a paraphyletic stock of other Gondwanan titanosaurians, in contrast to the Eurasian affinities of *Mansourasaurus*. Additionally, other caudal vertebral morphs were recovered and indicate the presence of gigantic titanosaurians during the Late Cretaceous of Africa, further supported by several large appendicular and dermal elements. Overall, the Lapur Sandstone sauropod assemblage suggests a Gondwanan, rather than Eurasian, signal.
Morphological disparity results from numerous intrinsic and extrinsic factors, from the genetic and developmental processes that generate variation to large-scale climate change and extinction. Unifying these aspects in comprehensive understanding of Osteopathic Medicine, Old Westbury, NY, United States of America; CHURCHILL, Morgan, University of Wisconsin Oshkosh, WI, United States of America; BEATTY, Brian L., NYIT College of Osteopathic Medicine, Old Westbury, NY, United States of America; CHURCHILL, Morgan, University of Wisconsin Oshkosh, WI, United States of America; SIMMONS, Nancy, American Museum of Natural History, New York, NY, United States of America; FOX, David L., University of Minnesota, Minneapolis, MN, United States of America; CURTIS, Abigail, American Museum of Natural History, New York, NY, United States of America; FABRE, Pierre-Henri, Université Watanabe, Akinobu, NYIT College of Osteopathic Medicine, Old Westbury, NY, United States of America; FABRE, Pierre-Henri, Université Watanabe, Akinobu, NYIT College of Osteopathic Medicine, Old Westbury, NY, United States of America

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University of Adelaide, and The University of Rochester, along with a wide variety of volunteers. Specimens from this cave have been used to elucidate floral change in the area, disentangle ancient food webs, and extend the hypothesized range for Beringian wolves.

Horses are the most common megafaunal group from this site, encompassing two genera: Equus and Haringtonhippus, the “New World stilleged” horse, based on post-cranial elements and mitochondrial DNA. To date, identification of species made from isolated teeth of equids has been unsuccessful. This study aims to test if isolated equid cheek teeth from Natural Trap Cave can be identified to the genus level, between Equus and Haringtonhippus using geometric morphometrics. 2D landmarks were taken around the periphery of a set of upper cheek teeth, including the areas of greatest curvature at the metastyle, mesostyle, parastyle, and around the protocone and post-protoconal valley. A principal component analysis separates the measured specimens into different groups. The first axis primarily shows variation in the size and orientation of the protocone. The angles and sizes range from parallel with the lingual side and short, to raised angulation and shorter protocone.

SPECIMENS FROM THIS CAVE HAVE BEEN USED TO ELUCIDATE

CHONDROCRAVIAL ELEMENT. TO DETERMINE WHICH EXTANT BIRDS ARE APPROPRIATE

THOSE OF PALEOGNATHOUS CASSOWARIES ALSO INCLUDE AN EXPANSIVE, MIDLINE

ORNAMENT CONFIGURATIONS CONSISTING OF PAIRED DERMATOCRANIAL BONES, WHILE

GREEN, Todd L., Oklahoma State University Center for Health Sciences, Tulsa, OK, United States of America; GIGNAC, Paul M., Oklahoma State University Center for Health Sciences, Tulsa, OK, United States of America

STUDIES OF DINOSAUR HEADGEAR THROUGH ANALOGY TO SOUTHERN CASSOWARIES AND NEOGNATHOUS BIRDS

GREEN, Todd L., Oklahoma State University Center for Health Sciences, Tulsa, OK, United States of America; GIGNAC, Paul M., Oklahoma State University Center for Health Sciences, Tulsa, OK, United States of America

GRANT INFORMATION:

NSF EAR/SGP 1425059 (Natural Trap Cave Revisited: Ancient DNA, Climate and the MegaFanal Extinction) Julie Meachen, PI

TECHNICAL SESSION XVII (Saturday, October 12, 2019, 11:15 AM)

ESTABLISHING A COMPARATIVE OSTEODEVELOPMENTAL FRAMEWORK FOR EVOLUTIONARY AND FUNCTIONAL STUDIES OF DINOSAUR HEADGEAR THROUGH ANALOGY TO SOUTHERN CASSOWARIES AND NEOGNATHOUS BIRDS

GREEN, Todd L., Oklahoma State University Center for Health Sciences, Tulsa, OK, United States of America; GIGNAC, Paul M., Oklahoma State University Center for Health Sciences, Tulsa, OK, United States of America

STUDIES OF AVIAN CRANIAL PHYLOGENY OFTEN CENTER ON BILL MORPHOLOGY AND ITS RELATIONSHIP TO TAXONOMY AND DIET. RELATIVELY LITTLE ATTENTION HAS BEEN GIVEN TO BONY CRANIAL ORNAMENTATION AND FUNCTIONAL MORPHOLOGY DESPITE THE APPEARANCE OF SUCH STRUCTURES IN AT LEAST 11 ORDERS OF EXTANT BIRDS. MAYBE THE BEST-KNOWN CRANIAL ORNAMENTS AMONG BIRDS BELONG TO CASSOWARIES (CASUARIID), WHICH HAVE SPADE-LIKE CASQUES THAT HAVE BEEN SUPERFICIALLY IMPLICATED IN NUMEROUS FUNCTIONAL ROLES (E.G., DISPLAY, VOCALIZATION, THERMOREGULATION). THESE STRUCTURES HAVE BEEN COMPARED TO CRANIAL ORNAMENTS ACROSS NON-AVIAN DINOUSAUR SPECIES (E.G., HADROSUARIES, OVIPTEROSAURS) IN ORDER TO DEVELOP HYPOTHESES ABOUT FUNCTION AND EVOLUTION IN THE FOSSIL RECORD. SURPRISINGLY, HOWEVER, COMPREHENSIVE DOCUMENTATION (I.E., INCLUDING ONTOGENY) OF THE INTERNAL AND EXTERNAL ANATOMY OF CASSOWARY CASQUES HAS NEVER BEEN CONDUCTED, WHICH HAMPERS SUCH INTERPRETATIONS AND SEVERELY LIMITS THE UTILIZATION OF CASQUES AS “LIVING MODELS.” TO REMEDY THIS ISSUE, WE EXAMINE ONTOGENY AND FUNCTIONAL CHANGE IN CASSOWARY BASAL CASSOWARIES AND NEPTORSAURS BY TRACKING THE 3D DEVELOPMENT OF INDIVIDUAL CASQUE ELEMENTS ACROSS AN EXTENSIVE GROWTH SERIES OF C. CASUARIUS, COMPARING CASQUE SIZE TO SKELETAL AND SEXUAL MATUREITY, AND FORMALLY DESCRIBING ORNAMENT VARIATION OF THIS ORNAMENT IN ADULTS. BECAUSE CASSOWARIES ARE THE ONLY KNOWN POISENS TO POSSESS BONY CRANIAL ORNAMENTS, WE ALSO EXAMINE ONTOGENIC SEQUENCES OF CAUSED NEONOGNATHS (E.G., MACROCEPHALUM, NUNIIDA). WE FIND THAT NEONOGNTHIC SPECIES SHOW ORNAMENT CONFIGURATIONS CONSISTING OF PAIRED DERMATOCRANIAL BONES, WHILE THOSE OF PALEOGNATHOUS CASSOWARIES ALSO INCLUDE AN EXPANSIVE, MIDLINE CHONDROCRAVIAL ELEMENT. TO DETERMINE WHICH EXTANT BIRDS ARE APPROPRIATE OSTEODEVELOPMENTAL MODELS FOR FOSSIL LINEAGES, WE NEXT SURVEY CRANIAL ORNAMENT CONFIGURATION IN NON-AVIAN DINOSAURS. OUR RESULTS SUGGEST A LINEAGE-SPECIFICITY FOR MODERN ANALOGS SUCH AS TREATED NEOGNATHOUS BIRDS ARE MORE ALIGNED WITH MOST NON-AVIAN DINOSAUR CRANIAL ORNAMENTS (E.G., EXPANDED DERMOCRANIAL FEATURES IN BASAL TETANURANS, PACHYCEPHALOSAURS), WHEREAS CASSOWARIES REPRESENT MORE APPROPRIATE ANALOGS FOR MANY LAMBEAURINES (E.G., DERMOCRANIAL AND CHONDROCRAVIAL FEATURES THAT CLADONATE TOGHTHER IN ONTOGENY). BY COMBINING PALEONTOLOGICAL AND NEONTOLOGICAL DATA, WE PROPOSE A SYSTEMATIC FRAMEWORK FOR SUBSEQUENT EVALUATION OF ORNAMENT GROWTH AND FUNCTION TO BETTER FACILITATE LARGE-SCALE COMPARATIVE STUDIES OF NEONOGTHIC COMPLEXITY IN THE DINOUSAR HEAD.
Unlike the avian cranium, which possesses apomorphic states throughout ontogeny, the pelvis evolved via modifications to relatively late developmental patterns, with early-stage embryos retaining a morphology similar to that of early theropod dinosaurs. Different regions of the avian Bauplan evolved via radically disparate developmental modifications. Extinct taxa are critical to correctly identifying the identity of ancestral and apomorphic features appearing during ontogeny.

**Technical Session XV (Saturday, October 12, 2019, 10:45 AM)**

**BIOSTRATIGRAPHY OF THE LOWEST MEGALODON IN THE MAIN KAROO BASIN, SOUTH AFRICA: IMPLICATIONS FOR MID- TO LATE-PERMIAN FAUNAL PROVINCIALISM AND KAROO BASIN DEVELOPMENT.**

**GROENEWALD, David P., University of the Witwatersrand, Johannesburg, South Africa; DAY, Michael O., Natural History Museum, London, United Kingdom; PENN-CLARKE, Cameron R., Council for Geoscience, Bellville, South Africa; RUBIDGE, Bruce S., University of the Witwatersrand, Johannesburg, South Africa**

The Beaufort Group of the Main Karoo Basin (MBK) of South Africa, with its wealth of tetrapod fossils, has been the focus of paleontological investigations for over 170 years and is considered to be the global standard for mid-Permian to Mid-Triassic continental biozonation. Currently eight vertebrate assemblage zones (AZ) are recognized. While fossil tetrapods have been reported from across the basin, the lowermost strata of the Beaufort Group have yielded relatively few fossils, particularly the area north of S31°10'. Reasons for this relative paucity of tetrapod fossils include a more attenuated stratigraphic succession in the distal (northern) sector compared to the proximal (southern) sector, coupled with the shortage of extensive exposures resulting from flatter topography and increased vegetation cover. Intensive fossil collecting in the lowermost Beaufort Group in the northern sector of the basin resulted in new distribution records for several genera. Our sample was augmented using fossil data from the Beaufort Fossil Vertebrate Database maintained by the Evolutionary Studies Institute (ESI), Johannesburg. Our study shows that the mid-Permian Tapinocephalus AZ extends further north in the MBK than previously recognized, and is directly overlain by the upper Cistecephalus or lower Daptocephalus AZ in the southern Free State Province. In the central and northeastern Free State, the Daptocephalus AZ is the oldest Beaufort Group vertebrate biozone present. Interestingly, the faunal composition of the Tapinocephalus AZ at its northernmost reaches differs from that of the south. This suggests that contemporaneous faunas in the MBK were not uniform across the basin and displayed more variation than currently appreciated. Furthermore, the juxtaposition of the lower Tapinocephalus AZ and upper Cistecephalus/lower Daptocephalus AZ in the southern Free State implies a stratigraphic gap from the middle to late Permian of up to 6 million years. These results have interesting implications for understanding faunal provincialism within Southern Africa during the mid- to late Permian as well as refining basin development models for the MBK.

**Preparators’ Session (Thursday, October 10, 2019, 2:15 PM)**

**DIGITAL AND MECHANICAL PREPARATION OF DELICATE SKELETAL REMAINS FROM AN UPPER CRETACEOUS BONEBED IN MADAGASCAR**

**GROENKE, Joseph R., Ohio University, Athens, OH, United States of America; O’CONNOR, Patrick M., Ohio Univ, Athens, OH, United States of America; DOUGAN, Lindsay, Denver Museum of Nature and Science, Denver, CO, United States of America; BURCH, Sara H., SUNY Geneseo, Geneseo, NY, United States of America; ROGERS, Raymond R., Macalaster College, St Paul, MN, United States of America**

We demonstrate an integrated methodology for using CT in both mechanical and digital preparation of field jackets collected from locality MAD 05-42 in Upper Cretaceous deposits of the Maevanarana Formation, Mahajanga Basin, Madagascar. Following in-quarry surface mapping, field jackets were documented in a medical CT scanner before mechanical preparation to provide preliminary identifications and spatial relationships of encased fossils. The initial scanning assisted in both prioritizing and in performing mechanical preparation. Specimens were prepared exclusively under magnification, using insect pins and carbide needles held in pin vices. Pin P-7 and B-72 was used for consolidation of specimens and adherence of fragments. Cyclophodacean served to stabilize elements during disassociation. Specimens too fragile to prepare entirely, or presumed to have delicate materials preserved below exposed and prepared materials, were micro-CT scanned. These data were then digitally prepared (segmented), providing high-resolution information on the spatial arrangements and anatomical details of materials too delicate to be exposed or removed from matrix. The workflow for this effort was coordinated between Ohio University and the Denver Museum of Nature and Science using two software platforms (Avizo and Dragonfly); it involved substantial processing by students and volunteers for...
initial segmentation, followed by quality control and data organization prior to study. As a result of preparition, associations of elements from individuals were demonstrable taphonomically (e.g., by connecting fragments of sternum prepared digitally and prototyped for confirmation of fits along pre-depositional breaks) and anatomically (by close physical association of non-overlapping elements, many of which were not visible on the mechanically prepared surface). We created high-resolution taphonomic digital reconstructions of materials across largely unprepared blocks of matrix. The two preparation approaches resulted in the defensible organization of discrete, dismembered anatomical elements into the contexts of individuals whose overall functional morphology, and phylogenetic relationships can be studied. We also produced prototype outputs of morphology that could not be replicated through molding and casting, resulting in 3D models for primary research and comparative work, as well as for dissemination and exhibition activities.

Grant Information:
National Science Foundation (EAR_1525915)
The fossil record is biased in space and time. Time intervals are unevenly sampled, and for any given interval, only a small portion of the Earth’s surface is preserved, biased towards depositional and taphonomically advantageous environments. Compounding this, taxon distributions are independently structured, functions of environmental tolerance and ancestral range. Evolutionary inferences must be made in the context of this incomplete and structurally biased fossil record, and while such effects are often considered in the context of richness, other aspects of paleobiology might be influenced by geographic biases. Diversification in an unsampled region cannot be observed directly and may present problems for inference of phylogeny, divergence dates, and rates of evolution. A slowly evolving clade that appears simultaneously in the fossil record as a result of changing geographic distribution has the same pattern of first appearance dates as one adaptively radiating faster than the frame rate of structured, functions of environmental tolerance and ancestral range.

In the context of richness, other aspects of paleobiology might be influenced structurally biased fossil record, and while such effects are often considered in the context of richness, other aspects of paleobiology might be influenced by geographic biases. Diversification in an unsampled region cannot be observed directly and may present problems for inference of phylogeny, divergence dates, and rates of evolution. A slowly evolving clade that appears simultaneously in the fossil record as a result of changing geographic distribution has the same pattern of first appearance dates as one adaptively radiating faster than the frame rate of structured, functions of environmental tolerance and ancestral range.

THE EVOLUTION OF PECULIAR CRANIAL MORPHOLOGY IN NASAL-EMITTING TRIDENT BATS (RHINOCYTERIDAE) FROM THE AUSTRALIAN MIOCENE

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In the fossil deposits of the Riversleigh World Heritage Area of northern Australia, trident bats (Rhinocytidae) and Old World leaf-nosed bats (Hipposideridae) are among the most speciose and abundant mammal taxa. Some 20 species of these bats have been identified in Riversleigh’s late Oligocene to middle Miocene karst deposits, and many are represented by hundreds of well-preserved skulls each. These kinds of bats emit pure-tone echolocation calls through the nostrils that allow detection of fluttering prey around vegetation, and have expanded nasal chambers and cochleae which are associated with energy transmission and reception. We used 3D geometric morphometrics to examine cranial traits in one of the most distinctive of these lineages, the Xenorhinus group. These extinct bats are characterised by a broad, deep rostrum, voluminous nasal cavities, incomplete nasal septum, broad, deep rostrum, voluminous nasal cavities, incomplete nasal septum, broad interorbital region, extremely short palate, splint-like sphenoidal bridge, and conspicuous rostral rotation. A 3D GMM approach enabled recognition of two new species referable to this group, reappraisal of the lineage’s probable phylogenetic relationships, assessment of their likely echolocation call attributes and ecology, and a possible developmental pathway for their unique skull form. Members of the Xenorhinus group represent ecomorphs that have been completely lost since the middle Miocene, probably as a result of changing paleoenvironments in northern Australia, but at least some of their striking cranial features persist in the extant trident bats of Africa and Madagascar.

Grant Information:
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A REVIEW OF THE MIOCENE RHINOCEROSES FROM JAPAN, AND PALEOBIOGEOGRAPHIC IMPLICATIONS

HANDA, Naoto, The Museum of Osaka University, Osaka, Japan

In Japan, the Miocene rhinocerotid remains have been well reported. Recently, the taxonomy of the rhinocerotids from Eurasia has been revised. In contrast, taxonomic revisions of Japanese remains have not been undertaken since their initial descriptions except for a few teeth and mandibular remains. Numerous rhinocerotid footprints have also been reported from the Miocene strata. The Japanese rhinocerotid fossil records give new information on the paleobiogeography of rhinoerotes in East Asia during the Miocene. However, a comprehensive discussion of Japanese Miocene rhinocerotids has not yet been carried out. Here I review the fossil records of the Japanese rhinocerotids from the Miocene and discuss their taxonomic status and distribution with the paleogeographic change of Japan island through the Miocene Period.
Brachypotherium? pugatorius, Plesiacatherium sp. and possibly a member of the Teleroceratidae have been found from the Early Miocene localities (20-16 Ma). Several fragmentary remains of the Early Miocene which were identified as Chilotherium are re-identified as an indeterminate taxon. All rhinocerotid footprints have been found from the early Miocene strata. A lower incisor which is of a member within the Acratheriinae is only from the Middle Miocene record (around 14 Ma). I recognize two Late Miocene (9-6 Ma) remains as members within the Acratheriina. An isolated molar from the early Late Miocene locality is identified as an indeterminate taxon.

In the Early Miocene proto-Japan was a part of the eastern margin of the Asian Continent. Various species of Plesiacatherium and Brachypotherium have been found from the Early Miocene localities in Eurasia. Therefore, Japanese ones imply that these two taxa distributed into the eastern margin of it is unclear that whether Japanese Late Miocene taxa are descendants of the Rhinocerotids presented in Japan islands during the Late Miocene. However, Proto-Japan re-connected Asian continent in the early Late Miocene. Japan suggest that rhinocerotids presented in small islands of proto-Japan. Proto-Japan re-connected Asian continent in the early Late Miocene. Rhinocerotids presented in Japan islands during the Late Miocene. However, it is unclear that whether Japanese Late Miocene taxa are descendants of the Early to Middle Miocene taxa or new immigrants from the continent in the early Late Miocene due to incompleteness fossil records.

A NEW BASAL EUSUCHIAN FROM THE GRIMAN CREEK FORMATION AT LIGHTNING RIDGE, NEW SOUTH WALES, AUSTRALIA.

HART, Lachlan J., University of New England, Armidale, Australia; BELL, Phil, University of New England, Armidale, Australia; SMITH, Elizabeth T., Australian Opal Centre, Lightning Ridge, Australia; SALISBURY, Steven W., Universiteit Queensland, Brisbane, Australia

The Australian Mesozoic crocodyliform record is sparse in comparison to other Gondwanan land masses. A single formally-named taxon is known from this interval: Isisfordia duncani (upper Albian of the Winton Formation, Queensland). A second taxon, ‘Crocodylus (Bottosaurus) selaslophensis’ (Griman Creek Formation, Cenomanian, New South Wales), described in 1917 based on a jaw fragment, is enigmatic, and its taxonomic affinities have never been fully resolved.

We present evidence of a new species of Isisfordia from the same location and stratigraphic interval as ‘Crocodylus (Bottosaurus) selaslophensis’. This new species, based on a partial braincase, presents at least one unambiguous autapomorphy of Isisfordia and several unique characteristics that differentiate it from I. duncani. The former holotype of ‘Crocodylus (Bottosaurus) selaslophensis’ is also referred to this new species. Central to this argument is the re-identification of the jaw fragment as part of the maxilla—rather than the dentary as was previously supposed—combined with the presence of an alveolar groove. Despite the shared presence of an alveolar groove with I. duncani, the two differ in the shape of the alveoli and tooth crown bases, suggesting differentiation at the species level. Furthermore, additional cranial and postcranial remains from the Griman Creek Formation, including a series of associated vertebrae, also show features consistent with Isisfordia and are potentially assignable to the new taxon.

The identification of a second, roughly contemporaneous species of Isisfordia demonstrates that the genus was well-established in eastern Australia during the mid-Cretaceous. Isisfordia is the first Australian Mesozoic archosaur with multiple distinct species, further underscoring the paucity of Australia’s Mesozoic terrestrial vertebrate fossil record. These discoveries are also significant as they extend the geographical and temporal range of Isisfordia, which has traditionally been considered the most basal taxon within Eusuchia.

Grant Information:
Phil Bell is funded by an Australian Research Council Discovery Early Career Researcher Award (project ID: DE170103125).

Using Comparative Anatomy, Taphonomy, and Phylogenetic Bracketing to Assess Rib Orientation in Non-Avian Dinosaurs

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Estimates of extinct animal volume, center of gravity, and extrapolations from that data (e.g., physiological modeling, reconstructing stance and gait) depend on accurately constraining volumes of individual body segments. This is particularly true of the torso, which is the largest body segment in nearly all tetrapods. Limb griddles and bony ribs provide the potential for accurate torso shape and volume estimates, but competing estimates of rib orientation relative to the axial column significantly after results. This is true whether estimates are made from multi-view anatomical diagrams or from three-dimensional LIDAR scans. Inspection of articulated non-avian dinosaur rib cages and undistorted isolated elements confirms previous reports that for anterior thoracic ribs, full seating of tuberculi and capituli against respective diaphyses and parapophyses results in rib shafts oriented posteroventrally in non-avian dinosaur taxa sampled. This result is consistent with X-ray data and dissections of extant crocodilians and avian-dinosaurs. As these taxa form an extant phylogenetic bracket, posteroventrally oriented anterior thoracic ribs in non-avian dinosaurs are a Level 1 inference. Diaphyses and parapophyses on the anterior vertebrae of dinosaurs are frequently offset from one another vertically and horizontally. As a result more posteriorly swept ribs also produce a narrower torso. Features of S. fatalis pectoral griddle of non-avian dinosaurs is dependent on the shape and anterior extent of the rib cage. Anterior thoracic ribs mounted or reconstructed in a vertical orientation requires the pectoral girdle to be moved anteriorly, functionally elongating the torso and shortening the neck. Calculating mass from competing inferences of rib orientation via double graphic integration shows a variance in whole-animal volumetric estimates of 8-10%. I suggest either adopting the well-supported Level 1 inference for non-avian dinosaur rib orientation, or for future authors to include these larger error bars into calculations that build upon shape or volume estimates.

Withdrawn

The Sound of Rancho La Brea

HARTSTONE-ROSE, Adam, North Carolina State University, Raleigh, NC, United States of America; ELMINOWSKI, Erin, North Carolina State University, Raleigh, NC, United States of America; FLORES, Deanna, North Carolina State University, Raleigh, NC, United States of America; ELDRIDGE, Emma, North Carolina State University, Raleigh, NC, United States of America

Fossils of Smilodon fatalis and Canis dirus from Rancho La Brea (RLB) tar pits are of immense interest to paleontologists. The large bones (the malleus, incus, and stapes) – merely a few millimeters each – have provided insights into the mechanisms by which these prehistoric predators hunter. Due to the preservation of these bones, we aimed to determine the range of frequencies transmitted through the living relatives of these extinct species. To test this hypothesis, we photographed 56 S. fatalis and 51 C. dirus auditory ossicles from RLB and digitally measured them and the ossicles of their living relatives (and some other RLB species) and found that the auditory ossicles of S. fatalis and C. dirus have similar shape and size characteristics of their modern relatives. While S. fatalis and C. dirus might have had similar hearing to their living relatives, we were also able to examine the auditory ossicles of the large extinct American lion (Panthera atrox) and found that its ear bones were substantially larger than those of any living cat species suggesting that it might have had very different – perhaps lower frequency – hearing. Other RLB taxa had ossicles that were so morphologically distinctive to be acoustically analyze. For instance, the giant ground sloths (Paramylodon, Megalonyx and Nothrotheriops) have no modern analogue remotely similar in shape and scale, and their well-preserved ossicles will require different technical approaches to assess their sound transmission properties.

Symposium: From Molecules to Macroevolution (Wednesday, October 9, 2019, 10:45 AM)

Calcium Isotopes and Dinosaur Resource Partitioning

HASSLER, Auguste, Laboratory of geology of Lyon: Earth, Planets and Environments, Lyon, France; MARTIN, Jeremy E., Laboratory of geology of Lyon: Earth, Planets and Environments, Lyon, France; AMIOT, Romain, Laboratory of geology of Lyon: Earth, Planets and Environments, Lyon, France; TACAIL, Théo, Bristol Isotope Group, School of Earth Sciences, University of Bristol, Clifton, United Kingdom; ARNAUD-GODET, Florent, Laboratory of geology of Lyon: Earth, Planets and Environments, Lyon, France; ALLAIN, Ronan, Sorbonne Universités—CR2P—MNHN, Paris, France; BALTER, Vincent, Laboratory of geology of Lyon: Earth, Planets and Environments, Lyon, France
Decades of field investigations in mid-Cretaceous continental assemblages of North Africa have provided extensive amounts of dinosaur fossils, among which theropods are the most numerous. The large representation of theropods in these environments led paleontologists to identify an "overabundance" of these dinosaurs compared to herbivorous ones. The co-occurrence of taxa such as abelisaurids, carcharodontosaurids and spinosaurids, in environments where herbivorous dinosaurs seem rare but where large crocodylomorphs are also present, raise numerous questions about the ecology of these faunas. How so many large predators could coexist with such few prey available? To address this question we investigated resource partitioning among such faunal assemblages using calcium (Ca) isotopes preserved in tooth enamel. Mainly extinct ecosystems. A focus on the mid-Cretaceous deposits of Gadoufaoua (Niger) and Kem Kem Beds (Morocco) has shown the distinct isotopic signature of spinosaurids, the most negative in our dataset. This observation partitioning between co-existing large predators. These, and other recently published results, should encourage further investigations of calcium isotopes in reconstructing ancient food chains.

Grant Information: Funding for this work was provided by the LABEX LIO (ANR-10-LABX-0066, ANR-11-IDEX-0007), J.E.M. DIUNIS project from CNRS-INSU, and the Jurassic Foundation Grant Program.

Regular Poster Session III (Friday, October 11, 2019, 4:15 - 6:15 PM)

**NEW FOSSILS OF ANTHRACOSUCHUS (CROCODYLOMORPHA) FROM THE PALEOCENE OF SOUTH AMERICA AND THE GEOGRAPHIC ORIGIN OF DYROSAURIIDAE**

HASTINGS, Alexander K., Science Museum of Minnesota, Saint Paul, MN, United States of America; MORENO-BERNAL, Jorge W., Universidad del Norte, Barranquilla, Colombia; WHITING, Evan T., University of Minnesota, Minneapolis, MN, United States of America; RINCÓN, Aldo F., Universidad del Norte, Barranquilla, Colombia; JARAMILLO, Carlos, Smithsonian Tropical Research Institute, Balboa Ancon, Panama; BLOCCHI, Jonathan L., Florida Museum of Natural History, University of Florida, Gainesville, FL, United States of America.

Previously described vertebrate fossils from the middle Paleocene (58–60 million years ago) Cerrejón Formation, northeastern Colombia, include a diversity of side-necked turtles, a giant boi d snake (Titanoboa), and three distinct genera of the extinct crocodyliform family Dyrosauridae, all previously unknown in the fossil record. Partial mandibles and skulls were recovered for the dyrosaurids Acherontisuchus and Cerrejonisuchus, but the mandible of Anthracosuchus has until now been unknown. Recent preparation of previously collected plaster jackets has resulted in the recovery of a large right mandible that exhibits a very large external mandibular fenestra (EMF), which in other dyrosaurids is either highly reduced or entirely absent. Teeth and alveoli of the mandible are very poorly preserved, leaving open questions about tooth count and relative spacing that could otherwise be used for diagnosis. Otherwise, the proportions of the jaw are fairly similar to what would be expected based on the skull of Anthracosuchus, as are associated teeth. Associated osteoderms exhibit the same great thickness and rectangular shape as those referred to Anthracosuchus (completely unique among crocodyliforms). Also recovered in association with the jaw was a well-preserved scapulocoracoid, which is entirely consistent with Anthracosuchus and indicates a broad, flat skull table with an enlarged supratemporal fenestra (STF). In different crocodyliform lineages, taxa often have either an expanded STF or EMF to house musculature to close the lower jaw. A taxon with both fenestrae enlarged would likely indicate a much more powerful bite than previously recognized for any other crocodyliform. The new morphology was scored and added to Anthracosuchus using a combined data matrix, which included 151 taxa scored for 476 characters. The addition of the new scorings shifted the relationships at the base of Dyrosauridae from the African Chenanisuchus as the most basal member to a sister relationship of Anthracosuchus + Cerrejonisuchus at the base of the clade. This would suggest that the family originated in South America, rather than Africa, which has been supported in all previous cladistic studies. Given that Late Cretaceous dyrosaurid remains have been recovered in Africa, this would further suggest an unknown lineage extending before the mass extinction event in South America.

Grant Information: Financial support from NSF EAR 1839102 and DEB 0733725, Smithsonian Tropical Research Institute Paleobiology Fund, Florida Museum of Natural History and Cerrejon Museum.

Education and Outreach Poster Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)

**3D PRINTING OF THE GIANT SNAKE TITANOBOA AS A MEANS OF STEM ENGAGEMENT IN HIGH SCHOOL PROGRAMMING**


Under-served schools often suffer from lack of opportunities for STEM integrated activities and therefore lack of student engagement in sciences and math. Projects that get students actively involved in STEM-based principles can have a dramatic impact on students' STEM identities, career goals and a general increase of science literacy. The University of Florida and the Science Museum of Minnesota recently partnered with Delta Charter High School in Aptos, California to implement a STEM program centered on the giant boid snake Titanoboa. This extinct relative of the anaconda was recovered from Paleocene sediments (about 60 million years old) from Colombia, in northern South America. Length estimates are roughly 13 meters, far exceeding the length of any other known snake.

Because hands-on lessons are more engaging and provide opportunities for STEM integration, hundreds of snake vertebrae were 3D printed in order to have students actively involved in the reconstruction of Titanoboa. Due to the incomplete nature of the fossil record, 3D scans of original Titanoboa vertebrae were resized to fill in the vertebral column. The skull and select vertebraal sections had to be further supplemented with 3D scans of modern anaconda (Eunectes murinus). This allowed for the team to create 250 3D-printed vertebrae, in addition to a skull, in order to 'recreate' for the first time the skeleton of Titanoboa. Students arranged each of these bones in class, and used them as part of a further lesson that teaches the students how to calculate body size based on snake vertebrae. An additional component incorporates the known relationships between body size and temperature in snakes, delving into the connection between climate change and the evolution of large body size in reptiles. Following simple regressions generated from the study's original data, students are able to estimate the size of the snake that belonged to 3D printed vertebrae and from that determine approximately how warm it must have been in order for that snake to have been alive. Students greatly enjoyed the lessons, reflected on engagement and interest, especially those students who normally do not engage in science. Furthermore, the students are currently planning their own traveling exhibit to visit a nearby elementary school and share what they have learned about climate change using the fossil record. The reconstruction is then planned to travel to other institutions to be used in STEM-based programs throughout the country.

Grant Information: Funding was provided by ‘DigFossils’, National Science Foundation Grant 1510410.

Romer Prize Session (Thursday, October 10, 2019, 11:00 AM)

**MAKING SPACE FOR GROUND SLOTHS: TESTING THE POTENTIAL FOR MODERN SLOTH STABLE ISOTOPE OFFSETS TO REINTERPRET GROUND SLOTH DIETARY ECOLOGY**

Haupt, Ryan J., University of Wyoming, WY, United States of America.

With only two extant genera, the current diversity of sloths belies that of their past, which includes species spanning several orders of magnitude in size, from a few kgs to multi-ton giants. However, a need remains for reliable determinations of their diet have implications for niche partitioning of sympatric megaherbivores as well as their role as ecosystem engineers with no modern analogues. As with other xenarthrans, sloths have evolved life history traits on the extremes of mammalian norms (e.g., slow metabolism, long digesta retention time, and emaciated-lesser teeth) that have complicated interpretation of stable isotope data for ecological insight. Prior analyses have used offset values from distantly-related ungulates to due a lack of data from modern xenarthrans. Here, I examined the stable isotope composition of various tissues from both genera of tree sloths (n = 16), which phylogenetically encompass most of sloth diversity. The benefit of this approach is that I can sample diet directly via stomach contents and feces, as well as tissues relevant to their fossil record like bone, hair, etc. While I calculated δ13C, δ15N, and δD values from a range of tissues, I found δ13C values of soft and mineralized tissues were the most useful for comparison to fossils because of better preservation potential and the utility of identifying
Collagen) are significantly different from previous estimates using ungulate Paleontology Challenge Grant. A complete list of backers can be found at.

The values indicating significantly more CAM and C₄ input in open or arid habitats, while spongy bones are associated with the hydrodynamic buoyancy control of active swimmers in the pelagic environment. Our study thus suggests that DPF elasmosaurs could have served a spongious inner core to the increased stress of floating to weight-bearing. Under the assumption that a postural shift occurs, forelimb element growth should respond to the increased stress of quadrapedality results in a functional change of the forelimb from free floating to weight-bearing. Under the assumption that a postural shift occurs, forelimb element growth should respond to the increased stress of quadrapedality. Recently, we performed a preliminary analysis of osteohistological characters of the humeri and constructed preliminary growth curves based on annual growth marks in the humeri. Here, we examined limb scaling through ontogeny in a large sample of Maiasaura humeri and tibiae to assess appendicular growth trends and to further test the ontogenetic postural shift hypothesis. Sampled Maiasaura tibiae and humeri were collected from a 2km² laterally expansive monodominate bonebed of disarticulated individuals within the Two Medicine Formation. Humeri were thin-sectioned at the region of least circumference, distal to the delto-pectoral crest, and aged by counting lines of arrested growth (LAGs). Age, body mass, and linear measurements from tibiae were derived from a previous study. Humeri were paired with tibiae based on similar numbers of LAGs. Ordinary least squares regressions were performed using body mass and linear measurements of appendicular skeletal elements as variables. Resulting inferences were based on the assumption that the paired humeri and tibiae reflected true growth trends without sexual size dimorphism or extreme individual variation. The resulting regression analyses revealed isometric growth patterns (regression line slopes of, or around, 1.0) of humeri and tibiae. Our results of isometric limb scaling patterns do not support the ontogenetic postural change hypothesis under the assumption that posture change requires non-isometric growth in regards to forelimb-hindlimb scaling. Examination of extant models is required to confirm these limb scaling requirements.

Grant Information: Funding for this project was provided by the Jurassic Foundation.

Technical Session XIV (Friday, October 11, 2019, 3:15 PM)

EVOLUTIONARY CONSTRAINT OF THE DIVERSIFICATION OF AVIAN LIMBS

HELLERT, Spencer, Field Museum of Natural History, Chicago, IL, United States of America; POLLY, P. David, Indiana Univ, Bloomington, IN, United States of America; RIHOA, Daniel P., Indiana University, Bloomington, IN, United States of America

Genetic and developmental factors (e.g., traits influenced by the same gene), and functional factors (e.g., traits of the same bio-mechanical apparatus) may integrate an organism’s traits so that selection cannot optimize its form for a given environment, creating tension between processes that promote anatomical diversification and those that promote integration. In this study, we used geometric morphometric methods to assess the extent to which integration has constrained the diversification of limb elements during the evolution of birds. Flightless birds have evolved many times, producing unrelated species that share similar limb morphologies, especially in the forelimb. In this study, we compared patterns of covariances in limb bones of flying and flightless birds as a measure of integration using geometric morphometrics, Mantel tests, Principal Components Analyses, Common Principal Components Analyses, Two Block-Partial Least Squares, and cluster analyses to determine whether patterns of integration are different in flying and flightless birds because of reduced functional demand or whether the two groups have a shared pattern of integration that is consistent with shared genetic and developmental constraints across all birds. A majority of analyses showed that flying and flightless birds have similar integration patterns within elements of both the fore- and hind limb. However, a number of the analyses, especially when phylogenetically independent contrasts were used, showed that patterns of integration between elements are different for flying and flightless birds.

The results support the hypothesis that integration patterns within the elements of avian limbs is constrained by developmental and genetic factors, regardless of flight ability. However, integration between bones may be influenced by functional factors. Therefore, the disparity of functional selection acting of the limbs of flying and flightless birds may promote diverse integration patterns within the limbs of the two groups, while shared genetic and developmental factors constrain the evolution of individual limb elements across all birds.
Ornithopods were small- (turkey-sized) to large-bodied (up to 16 tonnes) neornithischian dinosaurs with a fossil record extending for at least 100 Ma up to the K–Pg boundary and a global distribution. The East Gondwanan ornithopod record is limited to Early–middle Cretaceous Australia and to a lesser extent, Late Cretaceous New Zealand. Until recently only five taxa had been recognised from this region: the large-bodied Muttaburrasaurus (Albian) from Queensland; three small-bodied ornithopods, Atlascopcosaurus, Loolylmunasaurus and Qantassaurus (Barremian–Albian) from Victoria; and Fulgurotherium (Cenomanian) from New South Wales, although regarded as a nomen dubium. The past few years have seen an explosion of new information on Australian ornithopods—an enigmatic group that has historically been poorly understood. Here we update new discoveries and present new information revealed through CT imagery. Three new small-bodied Australian ornithopods have been named—Galleonosaurus and Diluvicursor (Barremian-Albian) from Victoria and Weewarrasaurus (Cenomanian) from New South Wales. Galleonosaurus and Weewarrasaurus are differentiated from other Australian ornithopods by their craniodental morphologies. Galleonosaurus is the first Australian dinosaur represented by an osteological series of maxillae. Diluvicursor, known primarily from a partial postcranium, is more robust than other Victorian ornithopod postcranial skeletons. Dental and internal anatomical differences between maxillary specimens revealed through 3D CT imagery further supports high taxonomic richness in the Victorian ornithopods. Remarkably, CT modelling of the Muttaburrasaurus cranium supports morphological convergence with the Laurusian lambeosaurines and a novel bone is identified.

Education and Outreach Poster Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)

USING FOSSIL SCIENTIFIC STORIES AS TOOLS TO ENGAGE STUDENTS WITH SCIENTIFIC LITERACY LEARNING OUTCOMES IN A CORE DEPARTMENTAL CURRICULUM

HINIC-FROLG, Sanja, University of Toronto Mississauga, Mississauga, ON, Canada; REISZ, Robert R., University of Toronto at Mississauga, Mississauga, ON, Canada

One of the main goals among different science departments is to engage students in scientific literacy and facilitate scientific literacy among students. At our institution, we have set scientific literacy expectations within our core departmental curriculum with the following learning outcomes: students should be able to identify and discuss scientific content; students should be able to use and evaluate the scientific method; and, students should be able to interpret data and evidence. In this presentation, we will showcase how we use different popular headlines about fossils to help students achieve these scientific literacy learning outcomes. We present students with popular headlines about a vertebrate fossil in different social media or news platforms across different courses in our department. Students are then tasked with identifying which specific words they would like to explore further. Next, students engage with the content relevant to each of these words to discover the scientific story about the fossil and to evaluate and discuss the science behind the popular headline. For example, for students in introductory classes, we use any vertebrate fossil discovery described next to words the “oldest” or the “largest”. Students then choose either the word “oldest” or “largest” to discover which scientific evidence is necessary to justify the use of either of these words, to describe the scientific methods necessary to collect data on either the fossil age or body mass, and to determine how these data on age or body mass can be interpreted. In upper year courses, scientific literacy learning outcomes are taught again by presenting headlines about either an environment or a particular behavior attributed to a fossil. This allows students to create scientific discussions about an environmental or behavioral interpretation of a fossil vertebrate. In addition to reiterating identification and interpretation skills by analyzing limitation and biases of data interpretation outcomes are both taught and assessed across our core curriculum.

OUTCOMES IN A CORE DEPARTMENTAL CURRICULUM

Technological session XX (Saturday, October 12, 2019, 2:15 PM)

DECIPHERING DEVELOPMENTAL CONSTRAINTS IN LIMB MUSCLES

HIRASAWA, Tatsuya, RIKEN BDR, Kobe, Japan; KURATANI, Shigeru, RIKEN BDR and CPR, Kobe, Japan

Basic pattern of vertebrate limb muscles was established in the lineage toward crocodyliforms, while a number of changes between the crocodyliforms and therapsids have mostly been conserved. Since the musculoskeletal connections are formed in development and unchanged during growth, their evolutionary stasis is likely attributable to developmental constraints. However, developmental mechanisms responsible for the constraints have been well understood. To solve this problem, we analyzed characterized of changeable parts in the developmental process of limb muscles through comparative and experimental approaches. We first focused on the exceptional evolutionary change of the pectoral muscle connections in the evolution of turtles. In chicken and mouse embryos, tendon progenitor cells expressing a transcriptional factor encoding gene, scleraxis (Scx), develop at
The connection between the sternum and pectoralis muscle. On the other hand, in turtle embryos, the pectoralis muscle is initially connected to the dermis without intervening Sca-positive cells, and secondarily attached to the plastron developing within the dermis. At the junction between the developing pectoralis muscle and dermis in turtle embryos, an expression of protocadherin Gene Fat1 was observed, as in the skeletal muscles connected to the dermis, such as the cutaneous maximus muscle, in mouse embryos. The same connection was also observed in the tongue muscle of mammals and anurans. From these lines of evidence, the evolutionary reconnection of the turtle's pectoralis muscle was evoluted likely through a developmental exaptation of an existing mechanism connecting a skeletal muscle to the dermis. Furthermore, we identified that the propatagialis muscle of birds, another exceptional evolutionary change, develops along the dermis of the propatagial membrane through the same developmental mechanism. The propatagialis muscle recurrently evolved in theropod dinosaurs and pterosaurs, possibly due to the same developmental exaptation to the turtles' pectoralis muscle. On the other hand, these examples of evolutionary deviations underscore the evolutionary stasis of musculoskeletal connection in tetrapod limbs in the absence of the dermal connection of a skeletal muscle, and its developmental basis should be studied in experimental embryology.

Grant Information:
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Regular Poster Session I (Wednesday, October 9, 2019, 4:15 - 6:15 PM)

TYRANNOSAURID TOOTH FROM THE LATE CRETACEOUS (TURONIAN) OF NORTHERN JAPAN

HIRAYAMA, Ren, Waseda Univ, Tokyo, Japan; TSUIHII, Takahiro, National Museum of Nature and Science, Tokyo, Japan; UNO, Hikaru, National Institute for Agro-Environmental Sciences, Tokyo, Japan

The bone bed of the Tamagawa Formation located in Kuji City, Iwate Prefecture, northern Japan, has produced numerous remains of both terrestrial and marine vertebrates of the Upper Cretaceous, with at least 20 taxa, such as turtles, crocodylomorphs, dinosaurs, choristodera. and Chondrichthyes identified so far. An estimated age of 90.51 ± 0.54 Ma (Late Turonian) is obtained for the bone bed based on U-Pb dating of the overlying volcanic ash bed. In 2018, a fragmentary crown of a left premaxillary tooth of a tyrannosauroid theropod (Dinosauria: Saurischia) was collected from this bone bed exposed at the amber-collecting site for visitors nearby the Kuji Amber Museum. The preserved crown is approximately 9 mm high and possesses a median ridge on the lingual surface with a D-shaped cross-section, a synapomorphy diagnosing Tyrannosauroidea. The crown carina lacks serration as in relatively few tyrannosaurid taxa such as Moros. Although approximately 30 genera have been described from the Middle Jurassic through the uppermost Cretaceous in the northern hemisphere, only few named taxa such as Moros and Timurlengia based on fragmentary materials are hitherto known from the early Late Cretaceous (approximately 100 million to 80 million years ago). Thus, present specimen, from this time interval, with a well-constrained geologic age estimate, is potentially important in analyzing diversity of Tyrannosauroidea by filling in the gap in the evolutionary history of this clade of theropods.

Technical Session XI (Friday, October 11, 2019, 1:15 AM)

COMPARISON OF 'BIG DATA' USES IN PALEOECOLOGICAL MULTI-PROXY MODELS FOR NORTH AMERICAN MAMMALIAN PALEOECOLOGICAL INTERPRETATIONS

HOCK, Devra G., University of Nebraska-Lincoln, Lincoln, NE, United States

The use of 'big data' has rapidly increased in recent years across paleoecology and paleobiology. ‘Big data’ can provide robust statistical analyses and a potential basis for answering broad scale questions, but may also suffer from the homogenization of important detailed information. The purpose of this research is to determine the viability of using the FaunMap (FM) and the Paleobiology (PBDB) databases for paleoecological reconstructions using multi-proxy models. Holocene North American mammalian data were downloaded from FM and PBDB. FM data consist only of locality information, while PBDB also has associated trait data. We test the viability of these datasets by evaluating their ability to differentiate among modern and Holocene biomes. Data from PBDB and FM were assigned to biomes based on their geographic occurrences within established ecoregions. Diet, locomotion, and body mass were assigned to taxa as traits. Principal component (PCA) analyses were run with and without small-bodied (<500g) mammals.

Across all analyses, we observe no clear association of traits with biomes. FM analyses show forest and semi-desert biomes significantly separating from each other, yet no clear trait associations within biomes are observed. Combined AMNH historical and FM data show slight biome separation among forest, grassland, and semi-desert. However, separation is not significant since 95% confidence ellipsoids overlap biomes. Combined occurrence data cover a greater area of North America, as AMNH and FM data has different geographic distributions. While AMNH data show an even distribution, semi-desert and desert biomes appear better sampled in the FM data. Combining these distributions better represents regional biomes and as such, more distinct results are not surprising. PBDB analyses also show significant separation between forest and semi-desert. Without small-bodied mammals, grassland appears separate from forest and semi-desert, though grassland does not have enough points for a confidence ellipse. In the PBDB data, grassland and semi-desert are severely underrepresented, and any results may be products of sampling resolution. The PBDB does not appear to have the resolving power or geographic distribution needed to model modern regional biomes using our methods. Both FM and PBDB cover the full Holocene, including some extinct megafauna and therefore characterize pre-human mammalian communities. To conclude, FM data do a better job at separating biomes, yet the lack of trait association is intriguing and must be further explored.

Education and Outreach Poster Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)

TIME IS OF THE ESSENCE: THREE CASE STUDIES FROM QUEENSLAND, AUSTRALIA, DEMONSTRATING RESPONSES TO FOSSIL SITE LOSS THROUGH MINING AND DEVELOPMENT OVER DIFFERING TIME SCALES

HOCKNULL, Scott A., Queensland Museum, Brisbane, Australia; LAWRENCE, Rochelle A., Queensland Museum, Hendra, Australia; CRAMBE, Jonathan, Queensland Museum, Brisbane, Australia; LANG, Paul, Queensland Museum, Brisbane, Australia; WILKINSON, Joanne E., Queensland Museum, Brisbane, Australia; SPRING, Kristen, Queensland Museum, Brisbane, Australia; SANDS, Noel, Queensland Museum, Brisbane, Australia

Responding to the potential or impending loss of fossil sites through mining and development can be a difficult and often unsuccessful process. In most cases, the length of time given to respond is the limiting factor. We present three case studies where highly significant fossil sites were discovered during mining and development works, each with different time frames for response, occurring over years, months or weeks. Due to limited legislative control over fossil site protection, the negotiation for successful access, documentation and salvage was undertaken directly between Queensland Museum (QM) paleontologists and the companies involved. Case 1 (2003-2004) occurred over a period of several months and required salvaging and stockpiling of thousands of tonnes of cave deposit exposed during limestone mining at Mt Elma, Rockhampton. These Quaternary-aged fossil deposits have since yielded hundreds of taxa, most new species, and led to the development of regional citizen science programs and events that directly utilise this resource. These deposits are now protected as part of the National Park. Case 2 (2013) occurred over weeks and was in response to a serendipitous discovery of fossil-rich Paleogene-aged oil shale deposits during road construction at Geebung, Brisbane. This deposit was rapidly assessed and stockpiled at QM Geosciences facility. Long-term (>5 years) weathuring and sieving of this deposit has yielded a diverse fauna, including new mammals, birds, reptiles, frogs, fish and invertebrates. It now forms the basis for QM Geosciences citizen science program. Case 3 (2008-2012) has occurred over years and is an ongoing relationship developed between QM and mining company BHP, at South Walker Creek Mine, west of Mackay. The fossils include a rare new suite of tropical megafauna and the world’s tallest kangaroo. Working with the mine since the original discovery by Traditional Owners has led to coordination site plans and staff involvement. Local and regional science engagement programs, such as UnEarthed, held during National Science Week, have evolved from these discoveries. Overall, the key to success in these three case studies was to: 1) rapidly disseminate the fossil site significance and undertake intensive subsampling and site data capture well before research publication; 2) directly involve the local community and company staff with the fossils through citizen science programs, and 3) collectively build a strategy to effectively stockpile the fossil resource (ex-situ) in a way that would allow access for future generations.
ON THE SHOULDERS OF TITANS: INTRODUCING NEW CRETACEOUS DINOSAUR FOSSIL FIELD FROM SOUTHWEST QUEENSLAND, AUSTRALIA, AND DEMONSTRATING THE UTILITY OF SCANNING (SURFACE AND CT) IN TAPHONOMIC AND ICHNOFOSSIL INTERPRETATION

HOCKNUL, Scott A., Queensland Museum, Brisbane, Australia; WILKINSON, Mel, Santos, Brisbane, Australia; LAWRENCE, Rochelle A., Queensland Museum, Hendra, Australia; NEWMAN, Nikki, Royal Brisbane and Women’s Hospital, Brisbane, Australia; MACKINZIE, Robyn, Eromanga Natural History Museum, Eromanga

Winton Formation (WF) surface fossil records are concentrated in the northern portion of the Eromanga Basin from a small number of sites near Winton and Isisford. This is in spite of the vast areas of mapped WF from western Queensland, eastern Northern Territory (NT), interior South Australia (SA) and northern New South Wales. Isolated faunal remains are known from the NT and SA sections of the WF, however, these sites have yet to yield remains of similar quantity to those from Winton or Isisford. Here we introduce two new fossil fields from southwest Queensland, near the remains of similar quantity to those from Winton or Isisford. Here we introduce two new fossil fields from southwest Queensland, near the towns of Eromanga and Quilpie, which preserve abundant faunal and floral remains. After 13 years of excavations, the Eromanga sites are dominated by sauropods including isolated dentition, trampled elements and articulated remains from differing body-sizes. Very large specimens represent a new taxon that differs from described taxa known only from Winton. Based on skeletal element dimensions, this taxon represents the largest dinosaur so far found in Australia. Another very well preserved semi-articulated skeleton is preserved within a concretion and includes most of the torso and tail. Confoundingly, a partial turtle and a single poorly preserved univalve bivalve represent the only non-sauropod body fossils. New ichnofossils are compared to northern records using a combination of photogrammetry and CT scanning methods. A cemented linear feature, ~100m long x ~4-5m wide, is interpreted as a ‘dinoturbated’ layer created by sauropods trampling sediment and underlying bones into a well-trodden ‘pathway’ or ‘pad’. A crush outline on a femur shaft resembles that of a manus with claw imprint. New three-track bipedal track sites from Quilpie show some differences to tracks from Winton, however, they were likely made by similar track makers. Using CT data, we observe small-sized bipedal dinosaur tracks from both Winton and Quilpie that are dominantly unidirectional across multiple phases of emplacement with each phase showing similar direction to others. This supports hypotheses of gregarious behaviours in small bipedal dinosauurs and evokes speculation about migration. We do not find evidence for swim tracks at these particular sites. Comparisons of the new records with others of similar age reveal that each possess localised depositional, taxonomic and taphonomic peculiarities. These peculiarities are likely governed by localised paleoenvironmental condition. Due to very poor stratigraphic resolution temporal explanations for these differences are limited.

Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)

SKELETAL ONTOGENY OF MASSOSPONDYLUS CARINATUS

HOLBACH, Brady P., Carthage College, KENOSHA, WI, United States of America

Massospondylus carinatus was a sauropodomorph that lived from the late Triassic to early Jurassic. Thirteen complete or nearly complete skeletons, including two embryos and a juvenile, have been found in the Elliot Formation in South Africa. The goal of this project was to recover the growth series for this species. Six specimens were coded for 12 binary and 2 multivariate characters using descriptions in the literature. One specimen, BP/1/4779, was removed from the analysis due to sharing the same coding with BP/1/5241. An artificial embryo was included as the outgroup. An exhaustive search retained one tree with 16 steps, CI of 1.00, HI of 0.00, RI of 1.00 and RC of 1.00. A total of 5 growth stages were recovered: Stage 1: large frontals, contact between the lateral maxillary ramus and the maxilla below the orbit, posterior ramus of the maxilla terminates posteriorly beyond the anterior margin of the orbit, contact between the jugal and quadratojugal is short; Stage 2: frontal has slight emargination for the edge of the fenestra, maxilla terminally is anteroposteriorly long, posterior ramus of the maxilla extends past the ventral midpoint of the orbit, contact between the jugal and quadratojugal increases in length; Stage 3: large nasals; Stage 4: the frontal nearly excluded from the orbital margin and the total number of teeth present is greater than 16 but less than 20; Stage 5: total number of teeth present is being greater than or equal to 20. A Spearman rank-order test showed a significant positive correlation between skull length and maturity with p value less than .001. A correlation coefficient was incautable due to there being no difference between mature individuals and size values. Tooth size data are normally distributed with a Shapiro-Wilk significance value of p=0.967. No evidence for sexual dimorphism is present in M. carinatus, as the ontogram shows no splitting of the specimens into two groups.

COlbert Prize Poster Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)

SIZE VARIATION IN POPULATIONS OF TETRACLAENODON (MAMMALIA, ‘CONDYLARTHRA’), FROM THE SANTA KLARA NALMA OF THE SAN JUAN BASIN, NEW MEXICO, REVEALS NEW INSIGHTS INTO THEIR EVOLUTION AND PALEO-ENVIRONMENT

HOLPIN, Sofia, University of Edinburgh, Edinburgh, Scotland; WILLIAMSON, Thomas E., New Mexico Museum of Natural History, Albuquerque, NM, United States of America; SHELLEY, Sarah L., Carnegie Museum of Natural History, Pittsburgh, PA, United States of America; BRUSATTE, Stephen, University of Edinburgh, Edinburgh, United Kingdom

After the end-Cretaceous mass extinction, approximately 75% of life on land and in the sea disappeared. The mammals of the early Cenozoic rapidly diversified and dispersed, rising to numerical and ecological dominance beyond their Mesozoic norms. Among those initial groups that ushered in the Age of Mammals, Paleocene and Eocene ‘condylarths’ are thought to include the ancestors of modern odd-toed ungulates (horses, tapirs, rhinos). Tetraclaenodon is the oldest genus of the ‘condylarth’ group Phenacodontidae and one of the most abundant fossils from the San Juan Basin (SJB) of New Mexico. Tetraclaenodon was a medium sized (mean body mass ca. 10kg), terrestrial mammal which was lightly built and had an omnivorous to herbivorous bunodont dentition.

Here we use multivariate and statistical analyses to investigate body mass and dental variation in 110 teeth of Tetraclaenodon spanning the Torrejonian (Paleocene) interval of the SJB. The specimens were grouped into six time bins by their biostratigraphical reference, from TJ1 (~63.8 Ma) through TJ6 (~62.7 Ma). Measurements of the length, mesial and distal width of the lower first molars (m1) were subject to principal component analysis (PCA), and m1 area was used to predict body mass using a regression equation. The PCA morphospace ordinates specimens along a PC1 axis that accounts for 90.05% of total variance and is significantly correlated with body size. A PERMANOVA test finds a significant difference in morphospace occupation (non-overlap) between clusters of specimens from TJ3-4 and TJ4-6, but there are no significant differences between the individual time bins within each cluster. This trend is also seen in the body size estimates: Mann-Whitney tests recover significant differences between the two clusters. These results suggest that Torrejonian populations of Tetraclaenodon were relatively constant in size throughout TJ1-3, but between TJ3 and TJ4 underwent an increase in body mass and subsequently stabilized (at this resolution) for the remainder of the Torrejonian. A similar trend is seen in contemporary populations of the periphytich ‘condylarth’ Periphytichus, suggesting that there were selective environmental pressures acting on these herbivorous species. These body size differences may reflect the emergence of a new, larger Tetraclaenodon species in TJ4, or may be associated to an environmental change, perhaps relating to climate or vegetation. In either case, this illustrates dynamic evolution of mammals during the few million years after the extinction.

Grant Information:
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Regular Poster Session I (Wednesday, October 9, 2019, 4:15 - 6:15 PM)

ASSESSING THE IMPACT OF SAMPLING BIASES AND TECTONIC CONTROLS ON PALEOGENE MARINE VERTEBRATES FROM THE EASTERN NORTH PACIFIC

HOLROYD, Patricia A., University of California Berkeley, Berkeley, CA, United States of America

The eastern North Pacific is an active continental margin characterized by accreted terranes and significant movement along long-ranging strike-slip faults systems that have produced a geologically complex coastline. The Paleogene record is poorly known but important for understanding Eocene-Oligocene faunal turnover and transition to colder water environments in the North Pacific. As part of a broader assessment of geographic and stratigraphic coverage of the eastern North Pacific marine faunas through the Paleogene, a new synthesis of the vertebrate record has been compiled from the published literature and new occurrences from a survey of museum collections. These new records range in age from late Paleocene to early Oligocene and geographically from southern Alaska to southern California. All occurrences were updated to current stratigraphic nomenclature and age assignments, and paleolatitudes estimated based on models developed for specific terranes and
faults. To assess whether vertebrate distribution is primarily controlled by accessible fossiliferous outcrop, number of localities/occurrences are compared with similarly updated molluscan occurrence data at the formation level.

Paleocene sites have a narrow distribution from 34.39°N latitude. Eocene sites expand this range to also include a cluster between 44-49°N and new records from southern Alaska. The latter are at 60°N today but at ~49°N in the Paleogene and transported along the Fairweather-Queen Charlotte fault. Both Paleocene and Eocene faunas are primarily shark teeth, with vertebrates occurring in fewer than 30% of fossiliferous formations. The sand tiger shark *Carcharias* is the most common taxon. Bony fish are often preserved as scales, and herring are most common. In contrast, Oligocene faunas are dominated by marine mammals. Oligocene vertebrate sites include a cluster at 22-23°N, another at 44-48°N, and an outlier in the Aleutian Islands that likely was deposited well south. The Oligocene is better sampled, with 62% of fossiliferous formations producing vertebrates. The comparatively lower diversity and number of vertebrate sites of the Paleocene and Eocene likely reflects a lack of sampling of available outcrops. No one region or depositional basin has a continuous record of Paleogene deposition. Accessible exposure strongly influences the distribution of faunas and is, in turn, a reflection of the active margin’s reorganization of accreted terranes. Analyses of North Pacific faunas require a detailed understanding of the tectonic history of the region.

Grant Information:
This work was supported in part by NSF ADBC award 1503678.

Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)

NEW SPECIMENS REVEAL A HIGH ELEVATION, LOW DIVERSITY MIOCENE TESTUDINOID COMMUNITY IN EASTERN IDAHO, U.S.A.

HOLT, Eric M., U.C. Berkeley, Berkeley, CA, United States of America

Miocene testudinoids have been poorly documented in western North America. Most of the published record of tortoises from the Miocene is either from the Great Plains or the inland valleys of Oregon and California; the record from the Rocky Mountain interior is particularly sparse. No Miocene testudinoids have been reported from Idaho, and only a very few have been recorded from Wyoming and Montana, east of the continental divide. Here I report on testudinoid materials from six localities in the Railroad Canyon Sequence of the Sixmile Creek Formation in south eastern Idaho, U.S.A.. This sequence spans 4.5 million years between 13.17-15.5 Ma, and today sits within the North American continental divide. The mammalian biostratigraphy, magnetostratigraphy and fauna have been previously published. Prior studies based on stable isotopes in precipitation estimated a hypsometric mean paleoelevation of 3.7 km (12,139 ft) at 39 Ma for the Sage Creek Basin, which includes the Railroad Canyon region. Leaf physiognomy analyses for the same area estimated a basinal paleoelevation of 2 km (6562 ft) at or around the same time. Railroad Canyon today is located at an elevation of ~1850 m (6140 ft) on the Idaho-Montana border west of the continental divide, and was almost certainly higher in the Miocene than at present. These assemblages have yielded one relatively complete shell with postcrania from a site that has been previously dated to the Barstovian (North American Land Mammal Age) and fragmented remains from five sites that have been assigned to the Barstovian NALMA. Analysis of the specimens indicates that diversity is low, and only one taxon is present at a given time. For the five Barstovian sites, the taxon present is Gopherus sp. based on the shapes of sulci found on fragmentary carapacial remains. This finding is important because it represents one of the highest elevation records for *Gopherus*, and is the first report of that genus from the Miocene of Idaho. This study is significant because it helps to fill a spatiodtemporal gap both in the North American testudinoid fossil record generally, and in our understanding of the Miocene distribution of *Gopherus* in particular.

Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)

EXPANDING CETIOSAUR DIVERSITY IN THE MIDDLE JURASSIC

HOLWERDA, Femke M., Utrecht University, Utrecht, Netherlands; POL, Diego, MEF, Trelew, Argentina; LISTON, Jeff, Yunnan University, Edinburgh, United Kingdom

The Middle Jurassic *Cetiosaurus* from the United Kingdom is historically the oldest sauropod described, with numerous phylogenetic and osteological analyses building on its information. Thus far, both Patagosaurus *fariasi* from the Middle Jurassic of Argentina and the contemporaneous Rutland *Cetiosaurus* from Leicestershire, United Kingdom, have been found to be nested within *Cetiosaurus*. However, *Cetiosaurus* is a classic ‘wastebasket-term’, with many specimens traditionally assigned to it, without having been examined in nearly a century. In addition to the holotype and associated material of *Cetiosaurus oxoniensis* from the Bathonian Forest Marble Formation of Oxfordshire, several other specimens from Gloucestershire and Skye have been investigated. The Gloucestershire material comprises several axial elements, including cervical and dorsal vertebrae, as well as pectoral, pelvic and appendicular elements. The Skye material consists of dorsal and caudal vertebral centra, as well as appendicular elements. As the Gloucestershire material originates from the Bajocian Lower Oxford Clay, underlying the Forest Marble, it is possible that it represents different taxa. Indeed, when compared to the holotype material of *Cetiosaurus oxoniensis*, they present significant osteological differences in vertebral and pelvic elements, specifically in cervical, dorsal, and ischial characters. The material from Scotland also originates from slightly older sediments, having been dated to the Bajocian-Bathonian. One character uniting the *Cetiosaurus oxoniensis*, Gloucestershire, Skye and Argentine material, however, is the presence of deep pleurocoels in dorsal vertebral centra, hinting at a degree of vertebral pneumaticity that is basal to that of neosauropods, but more complex for basal sauropods than previously assumed. This pneumaticity has thus far only been investigated for *Patagosaurus*, however, it is here shown to feature vertebrate distribution is commonly across the Jurassic period. Analyses using an existing datamatrix, adding new characters based on the pnumetic features, retrieve the Gloucestershire specimen as nested within *Cetiosaurus*, and as sister-taxon to *Lapparentosaurus* from the Middle Jurassic of Madagascar. The Skye material is potentially more derived than the latter two. These results suggest a significantly higher diversity in both cetosaurid and eusauropod taxa in the Middle Jurassic than previously believed.

Grant Information:
FH was supported by an OUMNH Visiting Fellowship

Technical Session VI (Thursday, October 10, 2019, 9:00 AM)

OLIGO-MIOCENE APLODONTIOID RODENTS REVEAL FAUNAL AND ECOCLOGICAL RELATIONSHIPS BETWEEN CENTRAL OREGON AND WESTERN MONTANA

HOPKINS, Samantha S., University of Oregon, Eugene, OR, United States of America; CALEDE, Jonathan J., Ohio State University, Marion, Marion, OH, United States of America

Small mammals show higher levels of endemism and smaller geographic ranges than their larger counterparts, and hence can often reveal details of ecological similarity that aren’t evident in whole faunas. Aplodontiod rodents are ecologically, morphologically, and taxonomically diverse in the late Oligocene and early Miocene of North America, and species and their distributions are often geographically narrow. These characteristics offer a good lens through which to examine ecological heterogeneity and faunal connectedness in western North America.

The John Day Formation of Oregon and Cabbage Patch beds (Renova Formation) of western Montana both preserve some of the best-known Arikareean small mammal faunas; both also have a diverse group of aplodontioids (roughly 10 species in each region) as some of the most common members of the small mammal assemblage. Comparing the material from the two assemblages in a single analysis allows us to recognize that, while the assemblages of aplodontioids in the John Day and the Cabbage Patch both contain multiple species and genera of alllomyine and meniscomyine rodents, there are some structured differences between them. The allomyine assemblages are similar, with Allomys and Abwoodia both represented in both assemblages, although the John Day assemblage has a slightly greater diversity of Allomys species. Allomyines are inferred to be terrestrial or arboreal, and have been suggested to be indicative of closed habitats. The meniscomyines, which are specialized for burrowing habits, are more different between Oregon and Montana and show possible ecological differences between the assemblages, as *Niglarodon* is present only in the Cabbage Patch assemblage, while *Meniscomys* and *Rudimos* are present in both assemblages. There is a greater diversity of meniscomyines in the Cabbage Patch assemblage, mostly composed of *Niglarodon* species, while the John Day has more different species of *Meniscomys* than the Cabbage Patch.

The abundance and diversity of aplodontioids in the faunas of Montana and Oregon is in contrast with well-sampled Arikareean assemblages from the Great Plains and California, which have far fewer aplodontioid taxa in the rodent assemblages. These diverse groups of species, some of which are shared between the two regions, are shaped by both biogeographic and biotic processes. They add important details to our picture of Arikareean landscapes.
BODY SIZE ESTIMATES OF SNAKE ORIGINS

ALTERNATE PHYLOGENETIC POSITIONS OF FOSSILS EFFECTS BODY SIZE ESTIMATES OF SNAKE ORIGINS

Hovatter, Brody T., University of Washington, Seattle, WA, United States of America; Wilson, Gregory P., University of Washington, Seattle, WA, United States of America

The Western Interior of North America documents the most complete record of early Cenozoic mammalian evolution following the end-Cretaceous (K/Tg) mass extinction event. Substantial work has been done to describe the taxonomic composition of mammalian faunas throughout the Paleocene in North America, spanning the Puercan, Torrejonian, Tiffanian, and Clarkforkian North American Land Mammal ages (NALMAs). The taxonomic composition of the Torrejonian is perhaps the most poorly known of these four ages, and is divided into three interval zones: the To1, To2, and To3. Few To1 faunas have been described in the literature, specifically from the San Juan Basin in New Mexico, Wasatch Plateau in Utah, Crazy Mountains Basin in Montana, and Williston Basin in Montana. Previous analyses of these faunas have revealed a considerable amount of provinciality, specifically between more northerly and southerly regions. However, it is unclear whether this is an artifact of sampling or reflective of paleoenvironmental differences.

Recent collecting efforts from To1 localities in northeastern Montana (TOM, hereafter) have yielded over 200 mammalian specimens. These sites have been calibrated to a relatively precise chronostratigraphic framework, and may represent the oldest known To1 fauna in North America. Moreover, previous work has shown that these sites may detail an early mammalian taxonomic and ecological radiation. Here, we compare the taxonomic composition of this important To1 fauna with other known To1 faunas from the Western Interior of North America. More specifically, we apply cluster and ordination analyses to presence and absence data from the TOM fauna and published faunal lists from the To1 of the San Juan Basin, Wasatch Plateau, and Crazy Mountains Basin. Our results indicate that the TOM fauna is unique, and contains several taxa previously known only from older time bins. Moreover, the TOM clusters most closely with the Crazy Mountains Basin, further illustrating the provinciality between more northerly and southerly faunas. Additionally, we observe some clustering between archaic ungulate and plesiopiform genera, with somewhat higher occurrences of the former in more southerly faunas, and higher occurrences of the latter in more northerly faunas. Taken together, these results add substantial detail to the biogeographic framework of this poorly sampled time interval, and contribute to our understanding of the pattern of mammalian faunal succession in North America, and illustrate the importance of broad geographic sampling.

Compositional differences of early Paleocene faunas in the Western Interior of North America and highlights North-South Provinciality

Hovatter, Brody T., University of Washington, Seattle, WA, United States of America; Wilson, Gregory P., University of Washington, Seattle, WA, United States of America

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Colbert Prize Poster Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)

ALTERNATE PHYLOGENETIC POSITIONS OF FOSSILS EFFECTS BODY SIZE ESTIMATES OF SNAKE ORIGINS

Howard, Alexandra F., University of Cambridge, Cambridge, United Kingdom; Head, Jason J., University of Cambridge, Cambridge, United Kingdom

Hypotheses of snake origins remain controversial due to conflicting data sets, distinct anatomical and ecological inferences, and problematic fossils. Two alternate ecological specialisations, fossoriality and aquatic swimming, have been proposed to be driving adaptations for the origin of the clade. Although a fossorial habitat has been shown to correlate with a reduction in body size in extant snakes, ancestral body sizes at the origin of snakes have not been investigated. Studies into body size reconstructions in other clades, namely mammals, have shown the importance of including fossil taxa in analyses, as these represent lineages with unique evolutionary histories which can profoundly change ancestral state estimations. To understand the role of fossoriality in our understanding of body size evolution in snakes and their implications for competing origin ecologies, we used Maximum Likelihood ancestral state reconstruction to model body sizes for Crown Serpentes and the total snake clade for both molecular and morphological phylogenetic topologies. Alternate placements of fossil taxa affected estimates of body size for the most recent common ancestor of all snakes. For example, inclusion of the Late Cretaceous snake Dinilysia patagonica as a stem snake greatly increased estimated body size of the most recent common ancestor of all snakes when compared to estimates resulting from analyses on extant snakes alone. Even when included as a stem alethinophidian, D. patagonica still increased estimates of ancestral body size for the snake total clade. These results are not consistent with a hypothesis that the ancestor of snakes was small scolecophidian-like but rather, though this does not preclude fossorial habits similar to extant aniloid taxa as an origin ecology. This study highlights the importance of fossil inclusion and placement when reconstructing evolutionary histories of phenotypic traits.

Grant Information:

Trinity Hall Graduate Studentship to AFCH

Regular Poster Session III (Friday, October 11, 2019, 4:15 - 6:15 PM)

FIRST COMPLETE SKULL THREE-DIMENSIONALLY RECONSTRUCTED FROM EARLY CRETAUCEOUS BIRDS

Hu, Han, University of New England, Armidale, Australia; O’connor, Jingmai, Institute of Vertebrate Paleontology & Paleoanthropology, Beijing, China; McDonald, Paul, University of New England, Armidale, Australia; Zhou, Zhonghe, Institute of Vertebrate Paleontology & Paleoanthropology, Beijing, China

During the evolution of crown Aves from non-avian dinosaurs the architecture of the skull underwent a number of important transformations. The evolutionary advantages imparted by these cranial modifications contributed to the survival of the Neornithes through the end Cretaceous extinction and ultimately facilitated their enormous current success. Although the fossil record of stem birds and their closest relatives has grown enormously over the past three decades, detailed cranial information is lacking due to the crushed, two-dimensional preservation of most specimens. The revolution brought by recent 3D digital visualization technology has the possibility to elucidate the cranial morphology of stem birds. Although widely utilized to study other vertebrate groups, these techniques have rarely been applied to early birds. As a result, details of the early evolution of the avian skull from the primitive avian theropod condition remain poorly understood. Using data from a new well preserved specimen we provide the first 3D reconstruction of the skull of the long bony-tailed bird Jeholornis, a taxon resolved just crownward to the basalmost avian Archaeopteryx. Although the skull of Jeholornis certainly holds important clues regarding its early transitional stage in the evolution from non-avian dinosaurs to birds, compared to Archaeopteryx it has received little study due to the bad preservation of previously reported specimens. This new skull is exquisitely preserved in 3D such that most elements are complete and articulated. The results of the digital reconstruction clarify several previously equivocal features such as the presence of completely fused premaxillae, the existence of a postorbital, and the presence of maxillary teeth.
indicates a mosaic cranial morphology. Shape and biomechanical analyses comparing ichthyosaurs to representatives of non-avian dinosaurs and extant neornithines provides the first quantitative insight into the early morphological and functional evolution of the avian skull.

Grant Information:
UNE Postdoctoral Research Fellowship; State Key Laboratory of Paleobiology and Stratigraphy, China (1833110); National Natural Science Foundation of China (41688103).

Technical Session XV (Saturday, October 12, 2019, 8:00 AM)
CONSTRUCTIONAL MORPHOLOGY OF THE SHOULDER GIRDLE AND OPERCULAR SERIES OF THE UPPER DEVONIAN TETRAPODOMORPH GOGONASUS FROM WESTERN AUSTRALIA

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High resolution computed tomography (HRCT) scanning and 3D printing were used to obtain a 3-dimensional digital reconstruction of the shoulder girdle and opercular series of the tetrapodomorph *Gogonasus* from the Gogo Formation (Franonian, early Upper Devonian, ~380 million years ago) of Western Australia. The Gogo fossil fishes are acid-etched from limestone nodules, and are exceptionally preserved in three dimensions. However, actual specimens are extremely fragile and difficult to manipulate – we scanned the most complete of four known *Gogonasus* specimens. Our findings show that the opercular series makes a close fit against the upper bones of the shoulder girdle only if the anocleithrum, supracleithrum and post-temporal are aligned more horizontally than previously reconstructed. The lowermost subopercular bone also largely covers the clavicle of the shoulder girdle, unlike all previous reconstructions. The ascending process of the clavicle, and the ventral process of the anocleithrum, do not fit closely inside the cleithrum. We suggest they functioned for ligamentous attachment. A rugose area on the anocleithral process has a similar relative position to muscle ligament attachments on the shoulder girdle of various living actinopterygians. Our work on manipulation of 3D printouts permits functional testing of extremely fragile acid-etched bones, and indicates a new way to investigate the constructional morphology of one or more functional units of the vertebrate skeleton. It is suggested that HRCT scanning and 3D printing techniques will play a major role in future research on functional analysis, testing the highly complex functional systems of fossil vertebrates and providing a much more robust evidential basis for understanding the evolutionary process.

Grant Information:
This research was funded by Australian Research Council Discovery grants-DP0772138 & DP1092870; supported by the Chinese Academy of Sciences (Grant No. XDB26000000).

Colbert Prize Poster Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)
ENAMEL SCHMELZMUSTER INFLUENCES ENAMEL FRACTURE PATTERNS AND PROMOTES SHARPENING OF EVERGROWING INCISORS IN CASTOR AND CASTOROIDES

HUNT, Tyler C., Florida State University, Tallahassee, FL, United States of America; RINALDI, Caroline E., University of Texas–Southwestern, Dallas, TX, United States of America

The masticatory apparatus of the Late Pleistocene giant beaver (*Castoroides*) and the modern beaver (*Castor*) suggest interspecific differences in feeding biomechanics and realized niche. In addition to large size, *Castoroides* differs from *Castor* in incisor morphology, growth, and wear patterns, and relative jaw muscle sizes. Specifically, *Castoroides* displays: 1) incisors characterized by longitudinally-oriented enamel ridges corresponding to a corrugated dentin-enamel junction (DEJ) and serrated occlusal cutting edges, 2) extensive wear on medial contact surfaces of lower incisors that honed the pair into a common occlusal point that fit into a bowled-out area on the dentin occlusal surface of the uppers, 3) longitudinal growth and wear rates of uppers exceeding those of the lowers unlike other rodents, and 4) an expanded origin for the internal pterygoid muscles suggesting increased lateral jaw movements.

Notably, both genera show an inner enamel layer composed of moderately different Hunter-Schreger banding and an outer layer of radial enamel. We investigated whether the differences in enamel fabrics and loading resulted in variant fracture propagation using Vickers microindentation. In both genera, the outer fabric redirects fractures labio-lingually while preventing crack coalescence and medio-lateral propagation. The inner fabric shows bidirectional cracks localizing strain energy and “block” cleavage. The bipartite composite inhibits cracks from propagating completely through the enamel. Fracture patterns show distinct functions depending on the location along the incisor’s long axis. Proximal to the occlusal end, the fabrics promote whole-tooth structural integrity by inhibiting crack formation medio-laterally when placed under tension during biting. This served to prevent spalling of the enamel in conjunction with the corrugated DEJ. The propensity of the inner enamel to fragment relative to the outer enamel promotes war of the occlusal end into a three-tiered cutting edge composed of the enamel fabrics and the softer dentin. The differences in the enamel microstructure and incisal loading between these taxa are not reflected in the fracture data. However, additional findings: 1) show the two-part incisal enamel fabrics in these taxa have similar dual roles for whole-tooth structural integrity and promotion of occlusal sharpness, and 2) further demonstrate that fracture and tribological attributes of teeth are preserved in some vertebral fossils.

Grant Information:
AFOSR-UNR18-69

Regular Poster Session I (Wednesday, October 9, 2019, 4:15 - 6:15 PM)
ADDITIONAL THERIZINOSAUROID BONES COLLECTED FROM THE UPPER CRETACEOUS MIFUNE GROUP, KUMAMOTO, JAPAN

IKEGAMI, Naoki, Mifune Dinosaur Museum, Kumamoto Prefecture, Japan; SCANNELLA, John, Museum of the Rockies; Montana State University, Bozeman, MT, United States of America; TOMIDA, Yukimitsu, National Museum of Nature and Science, Tsukuba, Japan

Therizinosauroids are an enigmatic group of theropod dinosaurs which diversified in the Late Cretaceous of Asia. Here we report additional material representing a therizinosaur taxon collected from the Amagami Dam fossil site (Loc. 1004) in the Upper Cretaceous Mifune Group (Cenomanian-Turonian) in Kumamoto, Japan. Previously, a partial braincase and isolated teeth were reported from the Mifune Group. The partial braincase possesses a bulbous bassinoid housing multiple internal pneumatic chambers similar to those of *Enigmosaurus* and *Nothronychus* from the Bayan Shire Formation in Mongolia; both specimens possess a fused obturator process and cranial and caudal processes which have been considered autapomorphies of *Enigmosaurus*. The head of the partial right femur is dorsally inclined, extending at an obtuse angle from the long axis of femur. The bridging region between the femoral head and the greater trochanter is constricted in dorsal view. The combination of these characters is not found in other theropod groups except for oviraptorosaurs. Although additional specimens are required to resolve whether these elements could belong to a single individual, these additional therizinosaur specimens may provide new insight into the postcranial material of these animals and suggests the occurrence of an adaptive radiation of therizinosaur taxa along the eastern margin of Cretaceous Asia.

Grant Information:
This project is supported by Mifune Dinosaur Museum, Museum of the Rockies, and Saskawa Scientific Research Grant (No. 16-354G).
FIRST NON-ORNITHOTHORACINE FOSSIL BIRD (Theropoda, Avialae) FROM THE EARLY CRETACEOUS OF JAPAN: INCREASING OUR UNDERSTANDING ABOUT EVOLUTION AND PALEOBIOGEOGRAPHY OF STEM BIRDS

IMAI, Takuya, Fukui Prefectural University, Fukui, Japan; AZUMA, Yoichi, Fukui Prefectural University, Fukui, Japan; KAWABE, Soichiro, Fukui Prefectural University, Fukui, Japan; SHIBATA, Masateru, Fukui Prefectural University, Fukui, Japan; MIYATA, Kazunori, Fukui Prefectural Dinosaur Museum, Fukui, Japan; WANG, Min, Chinese Academy of Sciences, Beijing, China; ZHONGHE, Zhou, Chinese Academy of Sciences, Beijing, China

The Early Cretaceous non-ornithothoracid avialan fossils had been known nearly exclusively from the Jehol Biota of northeastern China. The relatively restricted occurrence contrasts with the worldwide distribution of Ornithothoraces throughout the Cretaceous, and it has been speculated that non-ornithothoracid avialan fossils were endemic to the Jehol Biota. Here, we report an exceptionally well-preserved skeleton of a fossil bird (FPDM-V-9769) from the late Early Cretaceous of Fukui, central Japan. The specimen represents the first non-ornithothoracid pygostylian outside of the Jehol Biota and increases our understanding about the evolution and paleobiogeographic distribution of these early lineages. FPDM-V-9769 was collected from the Aptian Kitadani Formation, which crops out in Katsuyama, Fukui, central Japan and is interpreted as a lowland meandering fluvial system. By applying the synchrotron x-ray computed tomography technique to FPDM-V-9769, we observed a set of skeletal features comparable to those in other non-ornithothoracid avialan fossils. For example, the pygostyle is robust and boomerang-shaped as in most other non-ornithothoracid avialans, and the ulna is shorter than humerus as in Archaeopteryx and confuciusornithids, resulting in short forelimbs compared to more derived avialans. Absence of lines of arrested growth in a thin cross-section of the ulna indicates that FPDM-V-9769 is skeletally immature and possibly less than one year old at the time of death. Phylogenetic analyses indicate that FPDM-V-9769 as a non-ornithothoracid avialan, and suggest that it possibly represents a new fossil lineage. Early branching of pygostylians. FPDM-V-9769 appears to have inhabited a lowland, warm-temperate fluvial system near the eastern coast of Asia, based on the paleoenvironmental reconstruction of the Kitadani Formation. In contrast, previous studies interpret the Jehol Biota as a group of organisms inhabiting a highland, cold-temperate lacustrine system in an inland region. Thus, FPDM-V-9769 suggests that the non-ornithothoracid avialan fossils were adapted to a diverse range of environment and more widespread than previously known within East Asia.

Grant Information:
The present research was funded by Prefectural Government of Fukui (# 28-11).

REGULAR POSTER SESSION I (Wednesday, October 9, 2019, 4:15 - 6:15 PM)

SHAPE TRANSFORMATION MODELS TO PREDICT THE EXTINCTION TIME OF MACACA NEMESTRINA IN JAVA ISLAND, INDONESIA

INSANI, Halmi, Kyoto University, Inuyama, Japan; TAKAI, Masanaru, Kyoto Univ, Aichi, Japan

The chronological point of extinction of Macaca nemestrina in Java Island, Indonesia still remains unclear, although the species is considered coextinct with Macaca fascicularis ~700,000 years ago on the island. In this contribution, we provide allometric scaling approach to predict the appearance possibility of M. nemestrina in 4,000 years ago on the island based on fossil macaque teeth found in archaeological cave of Gua Lawa. The occlusal outline of third lower molar of recent M. fascicularis (n=60) and M. nemestrina (n=72) were decomposed through Elliptic Fourier Analysis to know the dental size and shape differences of both species mainly expressed by Common Allometric Component (CAC) and Residual Shape Component (RSC). Semi-landmarks following the outline were acquired by recording 120 successive equidistant 2D coordinates. Spearman’s coefficient of correlation between CAC and RSC (Rs=0.0369, p<0.05) tested in M. fascicularis shows a moderate and significant positive correlation. In CAC, M. fascicularis displayed a buccolingually narrow, slender occlusal outline with more prominent shape of each cusp compared to M. nemestrina, while the RSC demonstrates the protoconid and metaconid are located more buccally in M. nemestrina than in M. fascicularis. The nemestrina-like molars discovered from the Gua Lawa cave suggests the species was existed in the island at least until 4,000 years ago.
hypothesis for an extant animal, we obtained a turning trackway of an extinct extant animal, giving a greater steer rate of the pes. Furthermore, we introduce a dynamic model to analyze a turning tetrapod. The equation of motion was derived for a planar 4-link model simplified a tetrapod. Rotation of the links corresponding to the limbs and frictional force at the ground contact of the leg tip provided locomotion of the tetrapod model. The inside and outside off-tracking were synthesized by numerical simulation, when the steer ratio of the forelimb and hindlimb was changed.

Grant Information:
Private University Research Branding Project of MEXT Japan entitled on OUS International Research Project on Mongolian Dinosaurs

Technical Session IX (Thursday, October 10, 2019, 2:45 PM)

SNAKE VERTEBRAL SHAPE AS AN ECOMETRIC METHOD, AND ITS IMPLICATIONS FOR SNAKE DISTRIBUTIONS AT LOCAL TO REGIONAL SCALES.

JACISIN, John J., Texas A&M University, College Station, TX, United States of America; LAWING, A. M., Texas A & M University, College Station, TX, United States of America

Ecometrics examine the community-level relationships between organismal functional traits and environmental factors across geographic and temporal scales. As such, ecometric methods are increasingly useful integrative tools for reconstructing past environments and understanding geologically short- and long-term organismal dynamics in the face of environmental perturbations. With a long (Miocene) history of extinct groups appearing regularly in the fossil record of North America, and a particularly close relationship to the environment as limbless poikilotherms, snakes are excellent candidates for developing herpetofaunal ecometrics applicable to modern and palaeontological datasets alike. Because snakes employ their vertebrae as the primary skeletal element to pursue prey and move through myriad environments, we elected to investigate the anterior shape of middle trunk vertebrae as an ecometric. We used geometric morphometrics to quantify vertebral shape with 23 homologous landmarks, generalized procrustes superimposition, and a PCA to extract shape scores for 118 extant snake vertebrae representing 118 snake species from the continental United States and Canada. Five of the first six PCs representing different shape variations showed significant relationships to ecology via a combination of phylogeny and ecomorphology, implying potential niche conservatism in North America snake faunas. Multivariate regressions of the first six PCs (~86% of shape variance) and bioclimatic variables suggest that vertebral shape shares closer relationships with temperature-related variables and ecoregion comparable to mammalian ecometrics (R^2 > 0.40) when compared to other bioclimatic variables or vegetation cover. However, maximum likelihood models of AP performed better than those of MAT, suggesting a nonlinear relationship between mean vertebral shape and AP, likely via ecoregion. Finally, we constructed ecometric spaces consisting of the first six PCs, MAT, and AP, and included case studies of snake populations, giving a greater steer rate of the pes. We found that both mean and standard deviation changed in those environments.

Technical Session VIII (Thursday, October 10, 2019, 3:45 PM)

OLD DOGS AND NEW: HOW DOMESTIC DOG SKULL SHAPE VARIATION MIRRORS THAT OF EXTINCT CANIDS

JACQUEMETTON, Christiane, University of California, Los Angeles, Los Angeles, CA, United States of America; JUIN, Mark, University of California, Los Angeles, Los Angeles, CA, United States of America; BIRD, Deborah, University of California, Los Angeles, Los Angeles, CA, United States of America; SCHONEBECK, Jeff, The University of Edinburgh, Edinburgh, United Kingdom; TSENG, Z. Jack, State University of New York at Buffalo, Buffalo, NY, United States of America; VAN VALKENBURGH, Blaire, University of California Los Angeles, Los Angeles, CA, United States of America

As a result of artificial selection, the skulls of domestic dogs display a remarkable amount of variation relative to that of their ancestor, the gray wolf (Canis lupus). In fact, the disparity of skull shape in domestic dogs far exceeds that of entire family lineages within Canidae, despite having been generated in a relatively short period of time. However, extant wild canids represent only a fraction of the overall variation in skull shape that has been present over the history of the family Canidae. For example, there are skull shapes among extinct canids such as those of bone-cracking borophagines, (e.g., Borophagus), or short-snouted hypercarnivorous hesperocyonines (e.g., Enhydroycton), that represent canid ecomorphs that no longer exist. Can we find these ancient canid skull shapes within today’s domestic dogs, or do all breeds fall within a large but limited region of canid skull shape space? To explore this question, we compared skull shape variation across dog breeds and wild canids using landmark data from 117 wild canids, representing both extinct and extant lineages, as well as 40 domestic dog breeds. Landmark data was collected in ImageJ and processed in R 3.5.3 using the package geomorph. Our results confirmed the unique nature of several skull forms among the domestic dogs, including the elongate skulls of greyhounds and the round skulls of chihuahuas. However, other skull shapes seem to be less unique than previously thought. For example, Boxer and Rottweiler actually converge on a robust skull form similar to that of extinct bone-crackers such as Borophagus. Selection for a stronger bite in both the dogs and extinct canids might contribute to the similarity in form, but it is also possible that the similarity reflects underlying constraints on cranial growth within the family Canidae.

Support from this study was provided by the University of Bristol’s Masters Paleobiology program.

Technical Session XX (Saturday, October 12, 2019, 3:45 PM)

STANDING ON THE FEET OF GIANTS: FINITE ELEMENT ANALYSES OF SAUROPOD DINOSAURS HIND FEET AND THE EVOLUTION OF GIGANTISM

JANNEL, Andréas, The University of Queensland, Brisbane, Australia; SALISBURY, Steven W., The University of Queensland, Brisbane, Australia; PANAGIOTOPoulos, Olga, Monash University, Clayton, Australia

The capacity of sauropod dinosaurs to withstand the tremendous mechanical forces placed on their feet as a result of their gigantism represents one of the
most challenging biomechanical constraints in the evolution of terrestrial tetrapods. Several qualitative hypotheses have been advanced to explain how the feet of sauropods could bear their massive weight and facilitate their locomotion (e.g., changes in bone robustness, posture, or soft tissue). Among these, the presence of a soft tissue pad beneath the bony elements of their hind foot has been proposed as one of the effective means through which excessive mechanical loads could be accommodated. However, quantitative evidence for the presence of a soft tissue pad has never been verified. In fact, the links between foot configurations (e.g., posture) and biomechanical function in sauropods have not yet been tested. In this study, we used finite element analyses to study stress distributions within the hind feet of Late Triassic to Late Jurassic sauropodomorphs. First, we tested the effects of different skeletal postures on the deformations and bending regimes of various sauropod hind feet, and subsequently investigated the effects of a soft tissue pad on identical morphotypes subjected to similar mechanical conditions. The results reveal that our sauropod hind feet models could not have maintained bone stresses that fall within realistic safety factors in the absence of a soft tissue pad. Our findings suggest that a soft tissue pad likely acted as shock absorber, somewhat analogous to the cushion properties found in the foot of extant large-bodied mammals, such as elephants. Most importantly, our findings, coupled with a survey of the fossil record, suggest that sauropods may have evolved a soft tissue pad within their hind foot early in the course of their evolution by the late Early Jurassic–Middle Jurassic. The acquisition of this feature in early sauropods may have represented an initial and decisive evolutionary step, opening one of the pivotal doors for the achievement of gigantic body proportions in these terrestrial giants.

Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)
RECONSTRUCTION OF AN ANCESTRAL AMNIOTE TRACKMAKER BASED ON TRACKWAY DATA, TRACKMAKER CORRELATION AND PHYLOGENY
JANSEN, Maren, MN Berlin, Berlin, Germany; RENAUDIE, Johan, MN Berlin, Berlin, Germany; VOIGT, Sebastian, Urweltmuseum GOSKOP / Burg Lichtenberg (Pfalz), Thallachhöfen, Germany; BUCHWITZ, Michael, MN Magdeburg, Magdeburg, Germany
Trackway measures, such as pace angulation, pace length, stride length, gauge width, manus-pes distance (along track) and imprint orientation vary notably among amphibian, stem-amniote and early amniote tracks from Late Carboniferous to Early Permian deposits. Some of this variability can be attributed to evolutionary changes in trackmaker anatomy and locomotion style close to the origin of amniotes. This variability may be explored through phylogenetic approaches following the assignment of certain track types to distinct producer groups. Based on trackway averages of various parameters measured for eight tetrapod ichnotaxa from the Early Permian of the Thuringian Forest Basin as well as two additional Late Carboniferous ichnotaxa we infer ancestral states for functionally controlled trackway measures by means of parsimony and maximum likelihood. We use basal amniote trees from recent literature and consider two alternative trackmaker phylogenies, where: (1) diadectomorphs as probable producers of Late Carboniferous to Early Permian Ichnotaxon track types form the sistergroup to all amniotes; (2) they form the sistergroup of more derived synapsids within Amniota.
According to our results the ancestral amniote trackmaker had a body size higher than the sampled amphibian and reptilian track producers but was smaller than diadectomorph and early synapsid trackmakers. Its tracks were characterized by higher pace angulations, somewhat narrower gauges and lower normalized stride lengths than those of its non-amniote predecessors, whereas neither the normalized distance between consecutive manual and pedal imprints nor the orientation of the pedal imprints appear to have changed much on the amniote stem. The manual imprints were more outward positioned and had a more parallel orientation than those made by earlier stem-amniote producers. Early Permian Ichnotaxon trackways display certain similarities to contemporaneous synapsid tracks whereas other measures, most notably the orientation of manual and pedal imprints, differ considerably, demonstrating their limited use as model tracks of basal amniotes.

Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM)
TOOTH ATTACHMENT IN AN ACRODONT AMPHIBIAEHN (SQUAMATA)
JENKINS, Kelsey M., Yale University, New Haven, CT, United States of America; SCHWENK, Kurt, University of Connecticut, Storrs, CT, United States of America; BHULLAR, Bhar-Anjan S., Yale University, New Haven, CT, United States of America; GAUTHIER, Jacques A., Yale University, New Haven, CT, United States of America

'Acrodont' tooth implantation has historically been associated with several apomorphies in reptiles, but most often with teeth that are fused to the apices of the marginal tooth-bearing bones. But even reptiles exhibiting 'acrodonty' in the classic sense often display different modes of tooth attachment among clades. For example, acrodontan squamates 'acrodont' tooth replacement, while other 'acrodont' reptiles lack infilling and may or may not exhibit tooth replacement. Acrodonta and Sphenodon are often cited as exemplary taxa for this combination of traits, largely because they are thought to be the only extant taxa with 'acrodont' dentition. However, trogonodoph amphibians also possess these traits, although they are often overlooked in studies of reptilian dentitions. Our CT data confirm that Trogonophis wiegmanni possesses traits commonly associated with acrodonty, particularly the possession of the teeth in relation to the jaw bone, fusion between tooth and jaw, and the lack of tooth replacement. However, T. wiegmanni possesses other characters not seen in Acrodonta and Sphenodon, particularly the possession of alveolar foramina. The teeth of T. wiegmanni possess thicker enamel and dentine than most other reptiles, likely as an adaptation to resist wear. Histological data will confirm whether T. wiegmanni attaches its teeth in a similar manner as acrodontan squamates, or whether it displays a unique form of tooth attachment. Tooth implantation within Amphisbaenia varies in both extinct and extant taxa: this variation includes apparent transformations between more and less apical tooth positioning, fusion, and replacement.

Regular Poster Session III (Friday, October 11, 2019, 4:15 - 6:15 PM)
NEW DISCOVERY OF ANKYLOSAUR FOSSILS FROM SHANXI PROVINCE, CHINA
JIA, Lei, Institute of Vertebrate Paleontology and Paleoanthropology, Beijing, China; YOU, Hai-Lu, Institute of Vertebrate Paleontology and Paleoanthropology, Beijing, China; WANG, Zuo-zhu, Shanxi Museum of Geology, Taiyuan, China; XU, Shi-chao, Shanxi Museum of Geology, Taiyuan, China

The ankylosaur fossils of Shanxi Province, China were discovered formerly from the Late Cretaceous Huiquanzuo Formation of Tianzhen County. In 1998, two groups of researchers successively erected two genera, i.e., Tianzhensaurus youngi Pang & Cheng, 1998 and Shanxia tianzhenensis Barrett, You, Upchurch & Burton, 1998, based on two separate localities which are geographically close. The validity of these two genera was contentious (Sullivan, 1999; Upchurch & Barrett, 2000; Sullivan, 2000). Since 2011, abundant ankylosaur materials have been excavated by Shanxi Museum of Geology around northern Shanxi area. Through painstaking preparation and preliminary research, we have named a new ankylosaur dinosaur based on specimens found in Zaozun County: Jindipelta zaoozunensis gen. et sp. nov. (Jia Lei et al., 2019, in press). We also discovered a new morphotype of tail club for ankylosaur dinosaurs. In addition, new materials from Tianzhen are significant for solving the aforementioned 'validity' issues. All these new specimens will bring new insights to regional biostratigraphy and the evolution of Ankylosauridae.

Grant Information:
Our field excavation and indoor preparation are supported by Department of Finance of Shanxi Province.

Romer Prize Session (Thursday, October 10, 2019, 8:30 AM)
WHAT IS TELEOSAURIDAE AND STEGOSAURUS? THE TAXONOMY, SYSTEMATICS AND ECOMORPHOLOGICAL DIVERSITY OF TELEOSAURIDEA (CROCODYLOMORPHA, THALATTOSUCHIA)
JOHNSON, Michela M., University of Edinburgh, Edinburgh, United Kingdom

Teleosauridae was an extraordinary group of predominately shallow marine crocodylomorphs that thrived during the Mesozoic Era. While they have previously been considered the ‘marine carthals’ of the Jurassic, teleosaurids were in fact morphofunctionally diverse and evolved a bizarre body-plan (with proportionally enlarged heads and femora). During the Jurassic, they
attained a near-global distribution and became the first crocodylomorphs to
grow to truly giant size (>7 m in length). These were the first fossil crocodylomorphs to be described (1758) and named (1814).

Despite increased research over the past decade, particularly for the clade Machairodontinae, the ecology and systemsatics of Teleosauridae are still poorly understood and little studied. The question 'what is Steneosaurus?', a waste-basket genus that nearly every teleosaurid species has at some point been placed within, is a Gordian knot that has hampered previous attempts to elucidate teleosaurid evolutionary relationships. To rectify these issues, I examined approximately 530 specimens from 12 countries, and using these specimens, I created the largest and most comprehensive teleosaurid phylogenetic dataset to date. My expanded dataset includes 502 characters and 153 crocodylomorph taxa (twenty-seven of which are teleosaurids). This dataset was run in both TNT 1.5 and MrBayes.

The parsimony and Bayesian results are consistent, with two large subclades within Teleosauridae recovered; these are morphologically distinct, with differing biogeographic distributions (one being Laurasian and the other Sub-Boreal European-Gondwanan) and feeding strategies. There was a significant divergence in ecomorphological characters between these subclades. While the Sub-Boreal subclade attained larger body-sizes (≥5 m) and evolved durophagy, the Laurasian subclade was more phenotypically plastic (with an east-Asian freshwater clade, a nascent pelagic clade, and a heavily armoured clade). Based on my first-hand comparative anatomical and phylogenetic results, I propose major taxonomic revisions to Teleosauridae, including: (1) redefining Teleosauridae; (2) the resurrection of several historical genera; (3) erecting six new generic names; and (4) restricting the 'infamous' Steneosaurus to just a single species. With this new phylogenetic framework and updated alpha taxonomy reflecting teleosaurid anatomical and ecological diversity, a new window has opened on our understanding of these historically important crocodylomorphs.

Grant Information:
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Preparators’ Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)

PHOTOGRAPHS AND FOSSIL FILLINGS: A REVERSIBLE POLYESTER FILL AND UTILIZING NATIVE IPHONE APPS FOR COMPREHENSIVE PHOTO DOCUMENTATION

JOHNSTON, Scott R., American Museum of Natural History, New York City, NY, United States of America; DAVIDSON, Amy, American Museum of Natural History, New York City, NY, United States of America

When working with fragile fossils, it’s normal to encounter missing pieces that endanger the integrity of the section for or as a whole. To combat it’s common to fill these sections to provide support, stabilize and to allow for further preparation of the specimen. In working on a small nontongulate jaw, I needed to fill a missing chip of tooth on the inner edge of a crown. Bulked adhesives commonly used offer reversibility but overall were much too soft for my purpose. Epoxy putty would also be too soft on such a small scale. Polyester bulked with talc had the desired rigidity but isn’t easily reversible. The solution to this dilemma was the utilization a Parallel B-72 coating as a separator for the polyester, enabling removal if desired. In addition, the iPhone’s native Camera and Photos apps has proven very useful in reassembling fragmentary teeth. In the iOS 10 update, the “Markup” feature was added to allow the user to draw on images with their finger or a stylus. When reassembling complex projects with multiple fragments, it can be difficult to remember where each individual piece exactly fits over the course of multiple prep sessions. With this tool, it’s easy to trace, write notes, number, label and otherwise organize reference images. I utilized this method to photograph in situ pieces of a shattered bronchoeth tooth through a microscope and number the fragments for easier reattachment after prep. The Markup feature could be helpful with other types of extended projects. For example, it would allow for multiple people working on the same project to easily pick up where another person left off without having to relocate the fits.

Technical Session XV (Saturday, October 12, 2019, 8:30 AM)

THREE DIMENSIONAL SKELETONS OF MIDDLE JURASSIC STEM-GROUP SALAMANDERS FROM SCOTLAND, U.K.

JONES, Marc E., UCL, University College London, London, United Kingdom; HILL, Lucy E., Kings College London, London, United Kingdom; BENSON, Roger B., University of Oxford, Oxford, United Kingdom; EVANS, Susan E., UCL, University College London, London, United Kingdom

Salamanders comprise 600+ living species, are crucial components of many terrestrial ecosystems, and are frequent model organisms in studies investigating their response to toxicity, limb regeneration, and terrestrial locomotion. However, their early evolution and biogeographic history remain poorly known, limiting analyses of lissamphibian origins among Paleozoic tetrapods. Knowledge of early salamander anatomy is highly incomplete. The fossil record has improved in recent decades with both stem and crown group salamanders reported from the Middle and Late Jurassic (~12 taxa). Nevertheless, many of these records are incomplete isolated bones from screenwashing, or slab specimens. Here we report the recovery of six new salamander associations from the Middle Jurassic (Bathonian) of the Isle of Skye (Scotland). These belong to two species: Marmor押peton kermacki and ‘Kirtlington salamander A’. Both species were previously known only from isolated bones from the Bathonian of Kirtlington (England) and remained largely undescribed except for the gastric and some other vertebrae. The new specimens collectively comprise much of the skeleton, including partial skulls, atlantes, articulated vertebrae, complete limbs and girdle elements, extracted from micro-CT data. The presence of a possible operculum in one specimen highlights the exceptional nature of this material. These specimens include individuals of both M. kermacki and ‘Kirtlington salamander A’, and thus permit correct allocation of isolated Kirtlington bones to these species. M. kermacki has an atlas with an incipient interglenoid tubercle, hindlimb vertebrae with a deeply ornamented surface texture and no spinal nerve foramina, and a femur with a prominent trochanter. ‘Kirtlington salamander A’ has low rib facets, gracile roofing bones, and smooth bone texture. The new data suggests that both species are stem-group salamanders (Caudata) that help resolve the sequence of character state acquisition prior to origin of the crown-group (Urodela). Some features of ‘Kirtlington salamander A’ (e.g., no atlantal interglenoid tubercle; short, widely notochordal vertebrae) suggest that it is both more plesiomorphic than M. kermacki and neotenous. This possibility suggests the co-existence of neotenous and non-neotenous species among stem-group salamanders as early as the Middle Jurassic

Grant Information:
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Regular Poster Session I (Wednesday, October 9, 2019, 4:15 - 6:15 PM)

LAST NEANDERTHALS VS. HOMO SAPIENS: NEW PALEOENVIRONMENTAL AND PAEOCLIMATIC DATA USING THE SMALL VERTEBRATE ASSEMBLAGES FROM SERBIA (BALKAN PENINSULA, SE EUROPE)

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Serbia is located at the boundary between the Balkan Peninsula and Central European plains. Northern region of Serbia is a part of the Pannonian Basin, the terrain formed after the retreat of Paratethys. This event had a great influence on the composition of the Balkan fauna as retreating sea left behind a large plain (Pannonian Basin) that allowed central European species to migrate south and populate mountainous part of the Balkan Peninsula. In early Miocene dramatic tectonic activity gave rise to two mountain ranges. On the East there is a Carpatho-Balkan mountain range, and on the West, there is the Dinarides mountain range, both of which form karst landscape and are favorable for formation of caves. Fossil record in the caves reveals changes in fossil fauna from Pleistocene to Holocene. There is evidence that distinct configuration of the terrain in the Balkans forms many isolated areas, thus allowing large mammal species along with Neanderthals that were living in the area to find refuge and survive longer than in the rest of Europe. Best preserved fossil associations containing both herpetofauna and small mammal remains come from Brinjica, Chnošička, Habić, Podgora and Čavtina caves, and material that came from these caves is also most studied, best described, and most suitable for applying available methods. Archaeological excavations documented stratigraphical composition of layers within all caves dating from Late Pleistocene to Holocene. For multiple purposes some dates regarding the age of the layers have been obtained using the Accelerator Mass Spectrometry method, so an attempt has been made to create a chronological context within Late Pleistocene using available data which is in some cases very poor. Stratigraphical distribution of fossil assemblages corresponds to Gobet's MIS 4 to MIS 2 (i.e., from 70,000 to 14,000 years ago). Results were obtained using Taxonomical Habitat Indexes and Bioclimatic Analysis on small mammals. The Paleontological Statistics program (PAST3) has been used for all statistical approaches, with focus on Hierarchical Clustering, and Correspondence Analysis. The analysis showed that there were no dramatic
climatic oscillations during MIS 2 and MIS 3, and results suggest that the Balkans had the mildest climate during MIS 2 compared to Central Europe. Data obtained from Quaternary small vertebrate remains can be comprised in context of creating an image of the paleoenvironmental conditions, in that regard obtaining new data would allow us to expand paleoenvironmental reconstruction to MIS 4, for which we currently have insufficient data.

Grant Information: M. Jovanović is the beneficiary of a PhD scholarship funded by the Erasmus Mundus Programme - International Doctorate in Quaternary and Prehistory.

Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM)

THE STRUCTURE OF THE MAMMALIAN AND DINOSAURIAN HERBIVORE GUILD

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Understanding how communities are structured is a fundamental objective of ecology. Theory predicts that similarly sized species within a guild that compete for the same resource will exclude each other from local communities, but species of the same size can co-exist if resources are partitioned using a niche axis other than size. These mechanisms of species coexistence can thus be understood through an analysis of the shape of the body size distribution (BSD) of local ecological guilds. Terrestrial herbivores are diverse components of ecosystems, and occupy a wide variety of sizes, providing an ideal system to study how local environmental and ecological processes shape within-guild BSDs. To date, few models have been developed to predict how niche partitioning and competition will shape the BSD of a guild in a local community. Models based on resource allocation predicts differentially shaped distributions based on the availability and abundance of resources. Whether there is a general pattern in the shape of local herbivore BSDs is yet unknown. It is also to be determined whether mammalian herbivores and dinosaurian herbivores followed the same assembly rules in local communities. In this study, we sample local assemblages of terrestrial herbivores (from individual multitaxon quarries and bone beds) to determine the generalities and variability in the shape of mammalian and dinosaurian herbivore body-size distributions across space and time. Data on fossil assemblages were sourced from the NEOMAP, NOW, and Paleobiology Database. Body sizes of fossil taxa were estimated using allometric equations for skeletal and dental measurements. Sampling only artiodactyls, perissodactyls, and proboscideans, preliminary data from well-sampled North American Arikaree to Rancholabrean assemblages showed a remarkable amount of similarity in the shape of the BSDs among the land mammal ages (LMA). The average skewness of the BSDs for each land mammal age was close to zero, but positive for all LMAs. However, the assemblages did not have significantly different skewness among the LMAs. These results suggest that the terrestrial mammalian herbivore guild in North America is organizing in a similar way as an assemblage of the species that are occupying it. Further analyses will be conducted on mammalian assemblages from other continents and on dinosaurian herbivores.

Technical Session XII (Friday, October 11, 2019, 8:00 AM)

A NEW LAGERPETID ARCHOSAUR FROM THE TRIASSIC OF MADAGASCAR AND THE IMPORTANCE OF MINIATURIZATION IN ORNITHODIRAN EVOLUTION

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The 'basal Isalo II' beds of southwestern Madagascar yield a diverse fauna of latest Middle or early Late Triassic vertebrates, including multiple synapsids (traversodontid and chiniquodontid Cynodontia, Dicyonodontia) and archosauromorphs (Rhynchosauroidea, azhdarchosaur and Alloktorosaurus) lineages. Here, we present the first crown archosaur from the assemblage, representing a new taxon of lagerpetid ornithodiran. The new taxon is represented by the first confirmed craniodental material known for a lagerpetid (a maxilla) and a partial postcranium. The simple, conical teeth of the new lagerpetid exhibit pitted microwear consistent with a diet of hard-shelled, probably invertebrate prey. The new taxon's hook-like femoral head with a concave ventral margin identifies it as a lagerpetid, and its medially-angled fourth trochanter resembles that of Isalmapetos. It is distinguished from other members of the group, however, by its exceptionally gracile femur, which at ~38 mm total length makes it one of the smallest non-theropod ornithodirans. Osteohistological analysis indicates that this animal was at least 2 years old at the time of death and had reached or neared asymptotic growth, ruling out immaturity as the cause of its small size. The enigmatic probable ornithodiran Scleromochlus from the Triassic of Scotland appears to be a new taxon in its extremely small size. An analysis of ancestral body size in archosaur phylogeny incorporating these two taxa indicates a marked miniaturization event at the base of Ornithodira, with the earliest-diverging ornithodirans being substantially smaller than their nearest outgroups (aphanosaurs, crocodile-line archosaurs) and later ingroup ornithodirans (e.g., early dinosaurs). We propose that ornithodiran miniaturization was an important evolutionary event facilitating the development of bipedality and flight in the group, and may also be implicated in the early origin(s) of filamentous ('proto-feather') body covering.

Grant Information: Research supported by the National Geographic Society, American Museum of Natural History, and Field Museum of Natural History

Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM)

DISCOVERY OF A NEW RODENT ASSEMBLAGE FROM THE LATE OLIGOCENE IN JAPAN

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Small mammal fossils are efficient indicators of the paleoecolmiate and are often used in biostratigraphy. However, the Paleogene small mammal fossil record is very rarely identified in Japan. In this study, we report that a new rodent assemblage from Kyushu, Japan, has been found in the Late Oligocene Fuku Formation, Sasebo Group, in Nagasaki Prefecture. The fossiliferous layer is approximately 30-cm thick and contains transgressive lag deposit comprising granule-sized mudstone fragments, which unconformably overlie the coal-bearing nonmarine shale of the Sechibaru Formation of the Sasebo Group. The rodent specimens mainly comprise isolated teeth associated with the fragmental skeletal remains of crocodiles, tortoises, and freshwater fish. The assemblage includes four taxa, Cricetidae, Dipodidae, Sciuridae, and Castoridae. The relative proportions of the taxa based on isolated molar teeth (N=222) are Cricetidae (Euctricetodon sp.), 77.5%; Dipodidae, 21.2%; Sciuridae, 0.9%; and Castoridae (Sinoeotiber sp.), 0.5%. Probably, some of the aforementioned are new taxa. This rodent fauna, including abundantly occurring cricetids and dipodids and rare sciurids, resembles the Oligocene fauna of China and Mongolia. In the Late Oligocene, the Japanese Islands were situated in the eastern margin of Asia and, at the time, the Sea of Japan had not yet been widened. Hence, in the Late Oligocene, the Cricetidae- and Dipodidae-dominant faunas were extensively found in East Asia. However, Caninectidae, Eomyidae, and Gliridae are common taxa in the Eurasian Oligocene, they are not included in this rodent assemblage. It must take into account that the assemblage was affected by biases of the depositional and taphonomic setting of fossiliferous layer, but the difference in faunal composition between this assemblage and other East Asian Oligocene rodent fauna implies the difference in paleoenvironments between marginal areas and inner-continental regions of East Asia.

Grant Information: This work was supported by Kurashiki University of Science and the Arts Grant for Inter-Department Collaborative Research Projects. (for T. K. and H. Y.)

Romer Prize Session (Thursday, October 10, 2019, 12:00 PM)

THE APPLICATION OF PHYLOGEOGRAPHY TO INVESTIGATE POSSIBLE ANTHROPOGENIC TRANSLocations: A PRELIMINARY ANALYSIS OF THE CUSCUS (PHALANGERIDAE).

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The Phalangeridae are a family of arboreal marsupials found throughout Australia, New Guinea, Indonesia and Melanesia. Commonly referred to as cuscuses, the Asia-Pacific phalanger species have had a number of their island distributions attributed to prehistoric anthropogenic translocations. While some of these possible translocations are supported by archaeological evidence, most are lacking such data and questions regarding the timing and directionality of all these translocations remain. Here we propose a novel method to investigate the likelihood and directionality of these possible cuscus translocations based on phylogeography. We constructed the first dated, total evidence (molecular and morphological) phylogeny of the Phalangeridae incorporating modern, archaeological, and fossil taxa. This phylogeny was then run through the R package BioGeoBEARS to produce a
model of the family’s biogeographic history. This biogeographic model, in addition to the divergence estimates obtained from the phylogenetic analysis, were then compared with the archaeological records and palaeogeographical reconstructions to determine the likelihood of anthropogenic translocations vs. natural dispersals. We recovered good support for anthropogenic translocations of Phalanger orientalis breviceps and P. ornatus to New Ireland and Timor, respectively. We also found strong evidence to suggest that all other island populations of P. o. breviceps originated from the New Ireland population, not from additional translocations out of New Guinea. We find good support for a natural dispersal of P. ornatus to the Halmahera island group, rather than anthropogenic translocation. This study demonstrates the potential of this method for future investigation of prehistoric translocations on islands. A number of gaps in the available cuscus data are also identified and discussed as key areas for future research.

Grant Information:
Australian Archaeology Association Student Research Grant (Kealy), ARC Discovery Grant (Swanston 20100156), and ARC Discovery grant (Donnellen & Aplin: DP140103650).

Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)
CRETACEOUS POLAR MEIOLANIFORM RESOLVES STEM TURTLE RELATIONSHIPS
KEAR, Benjamin P., Uppsala University, Uppsala, Sweden; KOOL, Lesley, Monash University and Museums Victoria, Melbourne, Australia; LEE, Michael S., John Hopkins University and South Australian Museum, Adelaide, Australia; SNITTING, Daniel, Uppsala University, Uppsala, Sweden; RICH, Thomas H., Museums Victoria, Melbourne, Australia; VICKERS-RICH, Patricia, Swinburne University of Technology and Monash University, Melbourne, Australia; RABI, Marton, Martin-Luther University, Halle, Germany.

Meiolaniformes (Meiolaniformes) are an enigmatic radiation of stem turtles with an exceptionally protracted early Cenozoic record that spans the mid-Cretaceous (Apptan-Albian) to Holocene. Their fossils have been documented for over 130 years, with the most famous examples being the derived Australasian and southern South American meiolanids – bizarre horned turtles with massive domed shells and tail clubs that are thought to have been terrestrial and probably herbivorous. Despite a long history of research, the phylogenetic affinities of meiolanids have proven contentious because of ambiguous character state interpretations and incomplete fossils representing the most ancient Cretaceous meiolaniform taxa. Here, we therefore report the significant discovery of the stratigraphically oldest demonstrable meiolaniform remains, which were excavated from Hauterivian-Barremian high-paleolatitude (around 80°S) deposits of the Eumeralla Formation in Victoria, southeastern Australia. Synchrotron microtomographic imaging of multiple virtually complete skulls and shells provides a wealth of new data, which we combine with the most comprehensive meiolaniform dataset and Bayesian tip-dating to elucidate relationships, divergence timing and palaeoeological diversity. Our results reveal that meiolaniforms emerged as a discrete Austral Gondwanan lineage, and basally branching sister group of crown turtles (Testudines) during the Early Cretaceous (Santonian-Campanian). The most complete is preserved in three lamina, was used for osteohistological sections. The bone microstructure is fibrolamellar. The vascular channels have a similar diameter and do not show any sign of anastomoses. They are longitudinal and composed only by primary osteons. No growth marks are perceptible. These osteohistological features are consistent with what has been observed in pterosaurs. Although not diagnostic beyond Pterosauria, compared with other distal ends of wing phalanges, the wing span of this Antarctic flying reptile ranges between 3 and 4 m, what is compatible with the Pterodactyloidea. A third pterosaur element comes from the nearby Vega Island, more specifically from the López de Bertodano Formation (Maastrichtian). The specimen consists of an elongated bone with a D-shaped transverse section. The cortical is thin (~1mm) and the total preserved length reaches about 140mm. Despite incomplete, this material can be identified as a wing metacarpal IV. It is robust and elongated, allowing its allocation to the Pterodactyloidea. Both specimens demonstrate the presence of derived pterosaurs during the Upper Cretaceous Antarctica, indicating the cosmopolitan distribution of pterosaur in during the late Mesozoic Era.

Grant Information:
Funding for this project was provided by CNPq (PROANTAR #407670/2013-0 and #442677/2018-9) and FAPERJ (FAPERJ-26/202.905/2018).

Education and Outreach Poster Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)
THE PALEOANTAR PROJECT - COMBINATION OF SCIENCE, EDUCATION AND OUTREACH FOCUSING ON ANTARCTICA

KELLNER, Alexander W., Museu Nacional, Rio de Janeiro, Brazil; SAYÃO, Juliana M., Universidade Federal de Pernambuco, Vitória de Santo Antão, Brazil.

Antarctica is the continent of superlatives, being the coldest, the windiest, the driest, and the less explored of all. Expeditions to the "white desert" are hard to be carried out, expensive, time consuming and quite challenging from the logistic point of view, what gives any field activity in this region an adventurous and romantic aura, immediately capturing the interest of the public. For all when paleontology, particularly the search for fossil vertebrates, is the main focus of such an endeavor, what is generally associated with camping in an inhospitable region. Taking advantage of the natural public interest, the project PALEOANTAR (Paleontology in Antarctica) has explored several ways to engage the general public regarding the studies carried out in the "frozen continent". Right from its conception, despite the broad scope that the title suggests, scientific activities were restricted to the Antarctic Peninsula due to limitations of the Brazilian navy. The first version of this project was executed in 2006/2007, when nine researchers and two alpinists have spent around 40 days at the James Ross Island. At that time, this was the southernmost, the largest and the longest camp activity carried out by PROANTAR - the program that is responsible for all Brazilian scientific activities in this region. Two outreach and educational actions of different nature were developed. The first was the documentary "Expedition Antarctica - a summer of 70 million years" (55 minutes, in Portuguese) aired in 2008 and freely on Youtube (http://www.youtube.com/watch?v=1PzJzyDz7Ts). It shows scientists and students reporting their individual experience at the island. A second activity consisted in the temporary exhibit "Fossils of the frozen continent - the Museu Nacional in Antarctica", opened in December 2010, in Portuguese and English, the outline of this exhibit was of a ship, one side showing present environment and biota of the James Ross island and on the other plants and animals present in this region some 70 million years ago. With a hiatus of almost a decade, four consecutive field activities (2016-2019)
were implemented in the islands of James Ross, Snow and Vega. Again, a
documentary is being produced and a new exhibit was opened recently (2019)
etitled "When not all was ice - new discoveries in the Antarctic continent". 
PALEOANTAR has shown how scientific projects can also provide ways of 
education and outreach to the general public, strengthening the perception of 
the importance of Science.

Grant Information:
Funding for this project was provided by CNPq (PRONARE #407670/2013– 
0 and #442677/2018-9; #) and FAPERJ (#E-26/202.905/2018).

Symposium: Origin of a Sunburnt Country (Saturday, October 12, 2019, 
11:15 AM)
A UNIQUE ARTICULATED FOSSIL SHELDS LIGHT ON THE TAXONOMY OF TWO PLEISTOCENE SPECIES OF GIANT KANGAROO FROM THE GENUS PROTEMNODON.
KERR, I. A., Flinders University , Eden Hills, Australia

Prior to the extinction of the genus around 40,000 years ago, kangaaroos of 
the genus Promehnodon Owen, 1873 (Marsupialia: Macropodidae) were common 
members of mammalian herbivore assemblages across Australia and New 
Guinea. Of these, the mixed-feeding and grazing species Promehnodon brehus 
and P. roechus, found in open woodland and forest deposits from the 
Australian Pleistocene, were some of the largest kangaaroos ever at between 
~120 kg and ~170 kg. These two taxa are poorly delimited, with 
morphological descriptions relying heavily on variable dental characteristics, 
leaving significant grey-areas and lacking postcranial descriptions despite a 
wealth of postcranial material. Although P. brehus is described as smaller than 
P. roechus and differing in certain features of the cheek teeth, preliminary 
data from this study have suggested that these taxa may represent a single 
spatiotemporally widespread species. This study will utilise visualisation of 
craniodental and postcranial measurement data, morphological descriptions 
and geometric morphometric analyses of taxonomically significant areas, 
taken from a large sample of P. roechus and P. brehus, to test the taxonomic 
definitions of these taxa. An articulated fossil specimen in this study, that of 
a mother Promenodon brehus with a joey preserved while still held within 
the pouch, presents the rare opportunity to be certain of the sex of a fossil 
marsupial. With this unique fossil it will be possible to visualise the degree of 
sexual dimorphism in size in Promenodon brehus. It is possible that, given 
the significant size sexual dimorphism among medium- to large-sized extant 
kangaaroos species, the perceived difference in size between P. brehus and P. roechus is an artefact of sexual dimorphism within a single species.

Grant Information:
Supported by the Royal Society of South Australia Student Research Travel 
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Student Travel Grant.

Regular Poster Session III (Friday, October 11, 2019, 4:15 - 6:15 PM)
MIDDLE MIocene BOVIDS (MAMMALIA) FROM POTWAR PLATEAU, NORTHERN PAKISTAN
KHAN, Muhammad A., University of the Punjab, Lahore, Pakistan; ASIM, 
Muhammad, University of the Punjab, Lahore, Pakistan

New fossil boids are collected, described and discussed from the Middle 
Miocene of the Siwalik Group in northern Pakistan. The new material is 
collected from seven localities: Dhok Bun Amir Khatoon, Chini Reest House, 
Pawrewala, Lawa, Bibilmar, Rakh Wanasal and Jand. The fossiliferous 
localities, having the age of the Middle Miocene, are located in 
district Chakwal, Potwar Plateau, northern Pakistan. The taxa are consistent with a 
Middle Miocene age of the deposits. The specimens are classified on the basis of 
morphometric features and are assigned to eight boid species, namely Miotragocerus gluten, Tragopan salmoniatus, Helicopus traglephoides, Estragus sp., Elachistoceras kariustenensis, Boselaphini sp. indet., Gazella sp. and Sivaceros gradiens. Quantitatively, the specimens of 
Gazella and Miotragocerus are the most predominant. The smallest 
bovid Elachistoceras is uniformly rare. The new findings include the 
deciduous premolars of Miotragocerus gluten and Gazella sp. from the 
Chini Reest Formation of Pakistan. The specimens add substantial knowledge of the 
anatomical and metrical features of the described species. The bovid remains 
increasingly indicate both taxonomic and adaptive diversity. 
Biostatigraphically, the faunal composition suggests a Middle Miocene age 
(14.2-11.2 Ma). Based on the recovered faunal elements of Bovidae, it 
is proposed that the riverine and forest settings was found in the Siwalik Chini 
Formation during the Middle Miocene.

Grant Information: 
Subject: Request for Award/Grant of Scientist from Economically 
Developing Nation (SEIDN)

Colbert Prize Poster Session (Wednesday - Saturday, October 9-12, 2019, 
4:15 - 6:15 PM)
THE FIRST DISCOVERY OF REDFIELDIFORM FISH (ACTINOPTERYGI) FROM THE UPPER TRIASSIC AMISAN FORMATION OF KOREA AND ITS PALEOBIOGEOGRAPHIC IMPLICATIONS
KIM, Su-Iwan, Seoul National University, Seoul, Korea, Republic of 
(South); LEE, Young-Nam, Seoul National University, Seoul, Korea, 
Republic of (South); PARK, Jin-Young, Seoul National University, Seoul, 
Korea, Republic of (South); LEE, Sungjin, Seoul National University, Seoul, 
Korea, Republic of (South); LEE, Hang-Jae, Geological Museum, Korea 
Institute of Geoscience and Mineral Resources, Daejeon, Korea, Republic of 
(South)

A new genus and species of redfieldiform fish, Hiascoactinus boryengensis 
gen. et sp. nov., is described based on a nearly complete specimen from the 
Upper Triassic Amisan Formation of South Korea. Redfieldiforms are 
 freshwater fishes which have been reported from the Early Triassic to Early 
Jurassic deposits of many continents including Australia, Africa, North 
America, and South America, and have a fusiform body covered with ganoid 
 scales, a hatchet-shaped preopercle, a single plate-like branchiostegal ray, 
caudally positioned dorsal and anal fins, and a heterocercal caudal fin. This 
new specimen is distinguishable by a more fully developed but finely segmented 
fin structure suggests that Hiascoactinus did not have efficient 
turning maneuvers. All previously proposed Asian redfieldiform fossils are 
accurately classified, and consequently, Hiascoactinus is regarded as the 
only valid redfieldiform taxon in Asia. Hiascoactinus is assigned to the basal 
group of redfieldiforms primarily based on the presence of an antopectacle. The 
basal phylogenetic position of Hiascoactinus indicates that basal 
redfieldiforms dispersed from the southern Gondwanaland to the easternmost 
Laurasia through the terrestrial water system, and these two landmasses were 
connected to each other during the Late Triassic. This study represents the first 
scientific report of fossil fish from the Daedong Supergroup in Korea and 
gives new insight into the paleobiogeographic distribution of redfieldiforms 
during the Late Triassic.

Grant Information: 
This work was supported by the National Research Foundation of Korea 
(grant number 2016R1A2B2015012) to Young-Nam Lee.

Technical Session VI (Thursday, October 10, 2019, 10:45 AM)
ISOTOPIC VARIATION IN MODERN HOMINOID DIETARY 
NICHES: IMPLICATIONS FOR INTERPRETING THE FOSSIL 
PRIMATE RECORD
KINGSTON, John, University of Michigan, Ann Arbor, MI, United States of 
America; MACLATCHY, Laura, University of Michigan, Ann Arbor, MI, 
United States of America; MALONE, Maurie, University of Michigan, Ann 
Arbor, MI, United States of America

The utility of stable isotopic analyses of fossil material to reconstruct foraging 
strategy and habitat preferences of extinct taxa ultimately hinges on 
developing modern analogs to explore the complex biogeochemical links 
between diet, climate, and biogenic tissues. As isotopic research on fossil 
hominoids in tropical Africa has been extended into the middle and early 
Miocene, it has become increasingly critical to characterize and partition 
isotopic variability in potentially C3 dominated paleohabitats. To address this 
need, we systematically analyzed the isotopic signature of 228 well 
provenanced extant hominoid teeth to establish sources of variation and 
isotopic ranges for different niches. Multiple teeth of specimens of 
Pan, Gorilla, Pongo, Hylabates, and Symphalangus were bulk sampled to 
document inter-tooth variability related to life history patterns, intra-
population variability linked to variable foraging strategies, intra-species variability 
that reflects habitat differences, and inter-species variability
reflecting niche partitioning. Within these hominoid taxa inhabiting exclusive C habitats, there was significant interspecific variation ranging from a median δ13C value of -16.7% for Hylobates muelleri in Borneo to -13.3% for Gorilla beringei in DRC, in part reflecting a general trend of 13C enrichment linked to increasing folivory. The isotopic composition (both δ13C and δ18O) of the enamel of sympatric hominoids provided clear evidence of niche partitioning in some cases. At the highly seasonal site of Abai in Borneo, for example, orangutans (Pongo pygmaeus) had more variable δ13C values averaging over 2% more positive than the enamel of gibbons (Hylobates musculus), reflecting frugivory-differences and possibly greater water stress in the larger diameter and taller trees where Orangutans feed. δ18O values, however, were 5% more positive for gibbons, potentially reflecting increased drinking from terrestrial water sources by Orangutans. Interpopulation variation in 13C (from -11.2o to -8.8o) and -6% in δ13C in some individuals indicate either seasonal shifts in foraging strategy or variable diets linked to life history patterns. Collectively these data provide critical perspectives on the range of isotopic variation at the level of the individual to findings so far is that most evaluated characters do not encompass the full gamut of morphologies present in the dolphin lineage. For example, the acetabular wall is completely closed in forms such as Lagophthalmus; has a straight margin in Satamia; is partially excavated in Heterocephalus; is almost fully opened, with only a small round margin, in taxa such as Coloradisaurus; and fully opened in Eosuchus. Therefore, scoring the acetabular wall simply as present or absent does not represent the full variability of the trait and misses relevant information. Some characters have unclear homology series, such as the post temporals fenestra, as it remains unclear which of the reduced apertures of modified taxa represents the large plesiomorphic element. As for the femoral anterior trochanter, the plesiomorphic anatomy is unclear, as the element is absent in lagopterids. Its blade-like shape seen in ornithischians and neotheropods may not be homologous, as the structure in taxa such as Tawa differs not only from that of those modified forms, but also from those of sauropodomorphs, which have a possibly apomorphic diminutive trochanter. In the end, the observed morphology of the anterior trochanter does not support an unequivocal grouping of theropods and ornithischians. Moreover, when the so far modified scorings are included in the data matrices, Ornithoscelidea is not recovered, with a large polytomy uniting the major dinosaur groups being found instead. We hope that, with more comparative observations and scorings, the actual distribution of characteristics will be elucidated, and their phylogenetic signal made clear.

Grant Information:

Technical Session II (Wednesday, October 9, 2019, 10:30 AM)

HIGH-LATITUDE NEONATE AND PERINATE ORNITHOPODS FROM THE MIOCLEAN-PALEogene MASS EXTINCTION

KITCHENER, Justin L., University of New England, Armidale, Australia; CAMPIONE, Nicolas E., University of New England, Armidale, Australia; SMITH, Elizabeth, Australian Opal Centre, Lightning Ridge, Australia; BELL, Phil, University of New England, Armidale, Australia

Dinosaurs were remarkably climate-tolerant, thriving from equatorial to polar latitudes. In the Northern Hemisphere, eggshells and hatchling material confirm that hadrosaurid ornithopods were capable of reproducing in polar regions and remained resident throughout the winter season. However, similar examples and interpretations are lacking from Gondwanan landmasses. Here we present on two hatchling-sized non-iguanodontian ornithopod femora from the Grinnel Creek Formation (Cenomanian) in New South Wales, Australia. These two incomplete proximal femora represent the first perinatal ornithopods described from Australia, supplementing examples of neonatals and slightly older ‘yearlings’ from the Apiyan-Albian Eumeralla and Wonthaggi formations in Victoria. Although histological examination of these femora is obviated by opalization (i.e., pseudomorphic preservation), gross anatomical and size comparisons with Victorian specimens, which underwent previous histological work, support a perinatal interpretation for the Grinnel Creek Formation specimens. Both Grinnel Creek Formation specimens (reconstructed femoral lengths = 37 mm and 45 mm) are estimated to have been shorter in length than those from the Eumeralla and Wonthaggi formations (minimum length = 47 mm). Mass estimations for the two femora were 148-232 g, and 209–332 g based on their respective femoral circumferences. The small size and limited development of features (e.g., a low, crescentic fourth trochanter; absence of a distinct fossa trochanteris; absence of insertion scars for the M. iliotrochaneus and M. caudofemoralis brevis) in the smallest femur suggests that it may have been embryonic. Despite a period of rapid growth during the first few years of life, low body masses (~1 kg for ‘yearlings’ and ~20 kg at skeletal maturity) would have precluded such small-bodied ornithopods from undertaking long-distance migrations, even as adults. As a result, these specimens support high-latitudinal breeding in a non-iguanodontian ornithopod in Gondwana during the early Late Cretaceous. High-paleolatitude ornithopod nesting sites from both hemispheres reveals an apparent preference for wet, lowland settings suggesting the presence of constraints on egg incubation temperatures at high paleolatitudes, although preservational biases must also be considered.

Grant Information:
This work was funded through the University of New England and an Australian Research Council Discovery Early Career Researcher Award (project ID: DE17010325) to PRB.

Romer Prize Session (Thursday, October 10, 2019, 10:15 AM)

MOLECULAR AND MORPHOLOGICAL PATTERNS OF SURVIVAL, NOT EXTINCTION, OF SNAKES THROUGH THE CRETACEOUS-PALEogene MASS EXTINCTION

KLEIN, Catherine G., University of Bath, Bath, United Kingdom

Mass extinctions have played a vital role in shaping patterns of biodiversity throughout the Phanerozoic. The Cretaceous-Paleogene (K-Pg) mass extinction is the most recent and therefore the most influential on modern patterns of biodiversity. Recent advances in molecular clock methodology and discoveries of new fossils have permitted renewed evaluations of patterns of extinction and diversification of clades over the boundary. This has revealed that the recovery and diversification of mammals, birds, frogs, and teleost fishes shortly after the K-Pg boundary. However, it remains unclear how this event affected small poikilothermic reptiles, such as snakes. Here we investigate their survival and recovery through the K-Pg mass extinction using morphological disparity and molecular clock methods. We reveal a gradual increase in the disparity of snakes from the mid-Cretaceous to the Late Eocene, with increasing specialisation of marine paleopliods towards extreme lateral compression following the K-Pg, together with a concomitant shift in the region of the morphospace occupied. A molecular clock with up to 42 fossil calibrations demonstrates that snake diversification continued throughout the extinction event, with no marked shifts in rate. However, we highlight the importance of the calibration and model choices underpinning these results, as recovered ages vary significantly. Our results suggest that poikilothermy and burrowing or aquatic habitats increased the survival of snakes through the boundary. Niche use may therefore explain the differential impact of mass extinctions across major groups.

Grant Information:
This project was funded by the Fonds National de la Recherche Luxembourg AF grant 1014296.
IN THE LATE TRIASSIC OF WESTERN NORTH AMERICA
EXTINCTION-DRIVEN DROP IN ALLOKOTOSAUR DIVERSITY

STOCKER, Michelle R., Virginia Tech, Blacksburg, VA, United States of America; MARSH, Adam D., Petrified Forest National Park, AZ, United States of America; PARKER, William, Petrified Forest National Park, Petrified Forest National Park, AZ, United States of America

Archosauromorph reptiles are the most diverse clade of tetrapods from the Upper Triassic Chinle Formation of western North America, and they display the breadth of morphological evolution achieved by this group in its radiation after the end-Permian extinction. Allokotosaurs, including trilophosaurids, azendohsaurids, and Pamelosaurus dolichotrachelus, are an extinct archosauromorph clade of small to medium body size which reached a global distribution in the Late Triassic and evolved a broad range of cranial and dental morphologies. Allokotosaurs span the Norian-aged Blue Mesa (Adamanian biozone) and Sonsela (Revueltian) members of the Chinle Formation biozones. These biozones are punctuated by the Adamanian-Revueltian boundary in Arizona. These local patterns of archosauromorph clades including aetosaurs and phytosaurs across the Adamanian-Revueltian boundary in Arizona. These local patterns of faunal turnover with a drop in diversity from five taxa to one. The pattern of faunal turnover and extinction seen in allokotosaurs is similar to patterns in other archosauromorph clades including aetosaurs and phytosaurs across the Adamanian-Revueltian boundary in Arizona. These local patterns of extinction in both large- and small-bodied tetrapod clades demonstrate the magnitude of the Adamanian-Revueltian faunal turnover. The Manicouagan bolide impact (~215 Ma), which is coincident with the Adamanian-Revueltian boundary shows the extent of allokotosaur extinctions at the Adamanian-Revueltian boundary with a drop in diversity from five taxa to one. The pattern of faunal turnover and extinction seen in allokotosaurs is similar to patterns in other archosauromorph clades including aetosaurs and phytosaurs across the Adamanian-Revueltian boundary in Arizona. These local patterns of extinction in both large- and small-bodied tetrapod clades demonstrate the magnitude of the Adamanian-Revueltian faunal turnover. The Manicouagan bolide impact (~215 Ma), which is coincident with the Adamanian-Revueltian boundary, has been linked to marine invertebrate extinctions, and our findings add to the evidence for possible global ecological disruption associated with this event.

Grant Information:
Petrified Forest Museum Association
Petrified Forest National Park
David B. Jones Foundation

GEOMETRIC MORPHOMETRIC EVIDENCE FOR RAPID EVOLUTION AND STRONG DIVERSIFYING SELECTION OF PUTATIVE SIGNALLING TRAITS IN HORNED DINOSAURS

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Discoveries over the past few decades have greatly increased our knowledge of the morphological diversity of the horned dinosaur clade Ceratopsidae. This clade is known for the diverse and often complex arrangement of nasal and postorbital horns, and the shape and epiossifications of the parietal-squamosal frill. The Late Cretaceous experienced an apparent rapid increase in diversification of ceratopsian taxa, with diversity particularly notable in these putative display structures of ceratopsid skulls. Because the arrangement of these features is unique to each taxon, it has been suggested that the evolution and diversification of ceratopsian crania, particularly in the Late Cretaceous, is driven by these features. This points to a role in intraspecific socio-sexual interactions driving a form of runaway selection for increases in size and/or complexity for these traits. If this assertion is correct, quantifying the relative rates of evolution of different skull elements will allow us to test the hypothesis of accelerated evolution of ‘display’ traits, and help us to better understand patterns of evolution within this clade. Here, for the first time, we conduct a three-dimensional geometric morphometric analysis of ceratopsian skull morphology using high density landmarks sampled from over 80 specimens in more than 20 taxa. Using a maximum likelihood approach, we show that the ceratopsian skull shows a high degree of modularity, with the putative display structures forming distinct phenotypic modules. Morphological diversity in ceratopsians is largely a result of the diversity of phenotypic modules typically associated with display.

Using the Bayesian approach implemented in MCMCtree to deal with quantitative characters, we were further able to estimate divergence times of ceratopsian taxa under the Brownian diffusion model. We found that phenotypic modules and whole-skull data returned different estimates for branch lengths, and that those for the unique ‘display’ traits of ceratopsians are considerably higher than modules not considered to be associated with display.

These findings suggest that putative display traits did indeed undergo rapid evolution in ceratopsians and that they were under consistent and strong selective pressure, which both maintained their presence in ceratopsids and drove their diversification at the level of the taxon. This provides further support to the phenotypic module selection hypothesis of Fisher, adding support for the suggestion that these traits were important in socio-sexual interactions of ceratopsians.

Grant Information:
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PaleyNeuropology of a new theropod specimeN from the ‘argiles de l’IrhaZeR’, middle jurassic of nigeR

KNOLL, Fabien, ARAID—FCPDT, Teruel, Spain; LAUTENSCHLAGER, Stephan, University of Birmingham, Birmingham, United Kingdom; SERRANO-MARTINEZ, Alejandro, UNED, Madrid, Spain; ORTEGA, Francisco, UNED, Madrid, Spain

In 2006, a partial middle-sized dinosaur braincase was discovered at the Azenak site (Aderbissinat, Niger). The specimen comes from the ‘Argiles de l’IrhaZer’, which are possibly late Middle Jurassic in age. Although it was initially determined as belonging to a sauropod, a number of characters (such as a well-developed basiphenoidal recess) indicate that it pertains to a theropod. We CT-scanned this specimen and generated 3D renderings of the cranial endocast and inner-ear system. The endocast is characterized by a prominent fluscular lobe. This strengthens the identification of the specimen as a theropod, which was already apparent from observation of the external braincase morphology. Due to the incompleteness of the fossil, only the cranial nerves V to XII could be reconstructed. Large venous structures as well as the endosseous labyrinth could also be traced. Preliminary comparisons of the paleoneurology of the new dinosaur from Azenak with a variety of theropods for which the endocast is known shows resemblances with Allosaurus fragilis (Late Jurassic, U.S.A.). The Azenak theropod and Allosaurus display similar configurations of the caudal middle cerebral vein and blind dural venous sinus of the hindbrain. In both taxa, the vestibular system appears triangular with a fairly vertical crus commune in lateral view of the endocast. From this perspective, the horizontal semicircular canal and the caudal middle cerebral vein are parallel in both the Azenak theropod and Allosaurus. Most of these characters were previously brought to light as well in an isolated braincase of probable megalosaurid affinities from the latest Middle Jurassic of France. The combination of features shared by the Azenak theropod, Allosaurus and the Niger purported megalosauroid suggests that the Nigerien dinosaur may be a basal Tetanurae. The presence at Azenak of a megalosaurid close to (or identical with) Afrovenator abakensis, a Nigerien megalosaurid of possibly latest Middle Jurassic age (Tournaisian Formation), has been recently put forward on the basis of a few isolated teeth. Unfortunately, comparisons of the new specimen with Afrovenator cannot be made as no part of the braincase of the latter is known.

Grant Information:
This is a contribution to the research project CGL2017-89123-P funded by FEDER/Spanish Ministry of Science, Innovation and Universities-State Research Agency.
**Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM)**

**THE LAZARUS DICYNODONT – REASSESSING AUSTRALIAN CREATURES MATERIAL**

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The oftenesk, edentulous, and beaked non-mammalian therapsid dicynodonts were amongst the most abundant terrestrial herbivores during the latter half of the Permian and throughout the Triassic periods. Assumed extinct at the Triassic-Jurassic boundary, the discovery of a possible crested dicynodont (QM990) by a grazer in Queensland Australia, in 1914, potentially extended the longevity of the dicynodont lineage by nearly 100 million years. However, the very fragmentary nature of the specimen and the lack of information on its geological provenance, has so far prevented a definitive understanding of the taxonomical and temporal affinities of the material. Through recent reviews of museum correspondence archives and the use of synchrotron microtomography and geochemical analysis, new information has become available shedding light on the geographical and geological location, and the ecological context of this dicynodont. The results of this analysis, as well as review of the anatomical details, facilitates a better understanding of the material’s biological origins. These new findings impact on our knowledge of dicynodont evolution and biogeography, but also highlight the importance of specimen metadata and museums’ roles as custodians of these.

Grant Information:
The synchrotron microtomographic imagery was produced at the Australian Synchrotron facility in Melbourne, Australia as part of grant proposal ID AS182/2M3L/13304.

**Technical Session II (Wednesday, October 9, 2019, 11:30 AM)**

**A NEW CRESTED HAROSaurine (DINOSAURIA: HADROSAURIDAE) FROM THE MARINE DEPOSITS OF THE LATE CREATURES HAKOBU CHI FORMATION (MAASTRICHIAN), YEZO GROUP, JAPAN**

KOBAYASHI, Yoshitsugu, Hokkaido University, Sapporo, Hokkaido, Japan; NISHIMURA, Tomohiro, Hobetsu Museum, Mukawa, Hokkaido, Japan; TAKASAKI, Ruyu, Hokkaido University, Sapporo, Hokkaido, Japan; CHIBA, Kentaro, Okayama University of Science, Okayama, Japan; FIORILLO, Anthony R., Perot Museum of Nature and Science, Dallas, TX, United States of America; TANAKA, Koei, University of Tsukuba, Tsukuba, Ibaraki, Japan; TSOGTBAATAR, Chinzorig, Institute of Paleontology and Geology, Mongolian Academy of Sciences, Ulaanbaatar, Mongolia; SATO, Tamaki, Tokyo Gakugei University, Koganei, Tokyo, Japan; SAKURAI, Kazuhiko, Hobetsu Museum, Mukawa, Hokkaido, Japan

A nearly complete skeleton of a hadrosaurid dinosaur was discovered from the outer shelf deposits of the Upper Cretaceous Hakobuchi Formation (early Maastrichtian) of the Yezo Group in the Hobetsu area of Mukawa town in Hokkaido, Japan. This Hokkaido Hadrosaurid (HII) is important for understanding the diversity of hadrosaurids in marine-influenced environments because hadrosaurid material from these deposits are rarely reported. Given the completeness of this skeleton, this dinosaur also sheds light on understandings of the diversity of hadrosaurids in the Far East as well as spatial and environmental significance for the hadrosaurid evolution during the Late Cretaceous.

HII is a new taxon in having some unique characters (the midpoint of the quadratojugal notch positioned at roughly three-quarters of the total length of the quadratojugal, the first lower molar showing the beginning of the parastyle, the square upper molar showing the beginning of the parastyle, the square upper molar showing the beginning of the parastyle, the square upper molar showing the beginning of the parastyle, the square upper molar showing the beginning of the parastyle), our phylogenetic analysis shows that HII belongs to Edmontosaurini (a sub-clade of Hadrosauridae) and forms a clade with Laiyangosaurus and Kerberosaurus from the northern Far East. HII has a long horizontal platform for the nasofrontal suture surface, indicative of the presence of a moderate-sized supracranial crest, similar to a sub-adult form of Brachylophosaurus based on the extension of the nasofrontal suture surface. The histological section of the mid-shaft of the tibia exhibits at least nine lines of arrested growth (LAGs). In contrast, the marine reptiles have a higher variation in their δ18O values and average isotopic compositions to 3% lower than those of the fishes. This result is compatible with earlier studies and collectively suggests that these reptiles were able to maintain higher body temperature than ambient conditions. The δ18OCO3 values are also different between fishes and reptiles with higher values for the fishes. Both mosasaurs and plesiosaurs have very low δ18OCO3 values (<11.2 ± 2.2 ‰), n=12 and 11.8 ± 0.9 ‰, n=5, respectively), which cannot only be explained by their tritrophic level (i.e., diet) but are also linked to their respective phylogeny, relating to their diving habits. The two oxygen isotopic values, δ18O and δ13C, derived from enamel/enameloid correlate for the Antarctica samples (R=0.79), which may be taken as a sign of good preservation. Complete isotopic re-equilibration between the two oxygen bearing phases is highly unlikely in the view of preserved ecological differences between fishes and marine reptiles in their δ18OPo4 and δ13CCO3 values. Commonly the δ13CCO3 can be overprinted in the structural carbonate of the apatite, which is probably the case for the Patagonian samples. In view of the trace element content, especially the early diagenetic rare earth elements (REE) and uranium (U), all samples may have had a complex diagenetic history, indicated by their large variation in REE concentrations and distributions. Enamel/enameloid seems to be better preserved and reflect early depositional conditions, while in some cases dentine probably affected further by late trace element exchange maybe even during weathering processes.

**Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)**

**SMALL MAMMAL AND MOLLUSC FAUNAS FROM THE MIDDLE PLEISTOCENE OF CENTRAL RUSSIA**

KONDRAKHOV, Peter, A.T. Still University of Health Sciences, Kirksville, MO, United States of America; AGADJANIAN, Alexandre, Paleontological Institute, Moscow, Russia

The Middle Pleistocene deposits of the Central Russian Plain include three major moraines with an extensive series of alluvial deposits (MIS 18, 16, and 12) and loesses between them that produced rich small mammal and mollusc faunas. The main glacial stages on the Central Russian Plain correspond with marine isotope stages (MIS) 18 (Sel'yanin), 16 (Donian), 12 (Okian), and 6 (Moskovan) and correlate well with the glacial records from Central and Western Europe. Tiraspolian (=Cromerian) faunas of the Early Middle Pleistocene are known from the deposits of Petropavlovian, Pokrovian, Ilyinian, and Muchkapian horizons (MIS 20-15). Tiraspolian faunas known from below the Donian till (MIS 20-17) are characterized by the dominance of the vole Mimomys pusillus. Mollusc faunas of the lower part of the Tiraspolian complex are characterized by the presence of Tanosia krasnhenki, Viviparus diluvians, and Parafossarulus. The upper Tiraspolian faunas (MIS 15) are characterized by the dominance of the vole Mimomys intermedius, the presence of the gastropod Bathyentenia intermedia, and the absence of Tanosia and Parafossarulus. Transition between the Tiraspolian and Iloresitan faunas, which corresponds with the final stage of the Cromerian (MIS 13), was characterized by a significant faunal turnover with the disappearance of Mimomys and the first appearance of Arvicola. The most dominant rodent species in the Iloresitan faunas are Arvicola mosbachensis and Microtus voles. The evolutionary level of the latter corresponds with that of America during the Campanian may have played an important role for the hadrosaurid diversification in its early evolutionary history.
of Western European voles from the final stage of the Cromerian. The occurrence of Acicula polita in the fauna of Mustazhenka indicates that in the evolutionary lineage of Mimomys-Arvicola the loss of cheek tooth roots, and, thus, the differentiation of the genus Arvicola occurred prior to the Okian glacial stage during the final phase of the Cromerian. The Likhvinian (Holsteinian) mollusc faunas (MIS 11) are characterized by the disappearance of Boryssthenia intermedia and high terrestrial mollusc diversity. These faunas are similar to modern Central European faunas in the presence of Acicula polita and several chasist species. New data from numerous localities in the Central Russian Plain show a complex history of evolution of small mammal and mollusc faunas during the Middle Pleistocene, characterized by the appearance and disappearance of several taxa. The new data contribute to the development of a more detailed stratigraphic scale of European Quaternary continental deposits.

Symposium: From Molecules to Macroevolution (Wednesday, October 9, 2019, 10:15 AM)

 WHAT IS AN ‘EXCEPTIONAL’ FOSSIL? ASSESSMENT OF THE MICROSOPHIC PRESERVATION OF A JEHOL BIOTA FEATHERED Dinosaur

KORNEISEL, Dana E., Virginia Tech, Blacksburg, VA, United States of America; NESBITT, Sterling J., Virginia Tech, Seattle, WA, United States of America; XIAO, Shuai, Virginia Tech, Blacksburg, VA, United States of America

At the macroscopic scale, there is a clear range in fossil quality, and specimens which preserve soft tissues are typically considered exceptional. There is also a range in preservation quality on the histological scale; some environments preserve the fine details of single cells in phosphate or the structure of melanosomes on feathers. Some fossils even contain putative osteocytes and blood cells, which could be truly exceptional if valid. The molecular level is more difficult to assess preservation of as most organic molecules do not survive fossilization, and it is difficult to confidently identify even the most durable (i.e., collagen and lipids). The Jehol biota of Northeast China is composed of many classically exceptional specimens including well-feathered avialians with melanosomes preserved. These features make them clearly exceptional on the macroscopic scale, and at least notable for their cytological-scale preservation.

We have studied the Xixian Formation’s Beipiaosaurus inexpectus, a feathered therizinosaur from the Early Cretaceous, to assess whether exceptional detail at a macroscopic scale is necessarily indicative of high-quality cytologically and molecularly. To accomplish this assessment, we used a suite of analytical tools including Raman Spectroscopy, Energy Dispersive Mass Spectroscopy, and Time-of-Flight Secondary Ion Mass Spectrometry in addition to light microscopy of thin sections. These tools reveal some signs of high quality on the histological scale – fine details of canaliculi and little-altered apatite – and other indications of poor preservation conditions on the cytological scale including clay minerals in the vasculature. The purported blood cells are indistinguishable from other vessel fills chemically and do not contain any unique biomolecules. Extrapolating from this data, we conclude that the fine sediments of the Xixian Formation which preserve many of the exceptional Jehol fossils are not particularly well suited for preservation of blood cells or biomolecules.

Grant Information:
Geological Society of America Graduate Research Grant

Technical Session III (Wednesday, October 9, 2019, 1:45 PM)

AN EARLY ‘CAT GAP’? AN EVALUATION OF OXYAENIDS AS ECOLOGICAL ANALOGUES OF FELIDS

KORT, Anne E., Indiana University Bloomington, Bloomington, IN, United States of America

Oxyaenids were among the largest carnivorous mammals during the early Eocene. Their short-faced skulls and large carnassials resemble those of cats, characteristic of a hypercarnivorous diet. Oxyaenids became extinct in North America by approximately 43 Ma before the diversification of crown-group felids. This gap between the extinction of oxyaenids and the first appearance of cat-like carnivores approximately 39 Ma can therefore be considered analogous to the late period between the 43 – 17.5 Ma commonly referred to as the ‘cat gap’ due to the absence of cat-like carnivores in North America. Whether this earlier period can be considered analogous to the ‘cat gap’ depends on whether oxyaenids filled the same ecological role as cats. That the skull and dentition have similarities is established, but the function of oxyaenid postcranial elements needs to be resolved to completely compare their ecological role with cat-like forms. I made observations and measurements on the postcrania of a Patriofelis ulta from a nearly complete specimen (UMNH 550), as a representative oxyaenid to assess locomotor specializations in oxyaenids in comparison with felids.

The humerus of P. ulta resembles that of felids in having an expanded deltoid crest and wide capitulum. The expanded deltoid crest increases attachment area for adduction and abduction muscles, and the wide capitulum allows for supination of the forearm. In cat-like carnivores, strong, flexible forelimbs are used to grasp prey with prey, and it is likely this was the function in P. ulta. However, the lumbar vertebrae and feet of P. ulta differ from those of cat-like forms. The lumbar of P. ulta have revolute articulations with a restricted range of motion when compared with the lumbar of cats. The feet of P. ulta would have been plantigrade and lacked retractable claws, unlike the digitigrade feet in modern felids. While flexible forelimbs indicate that P. ulta could have been an ambush hunter that grappled with prey, P. ulta would have lacked the range of motion in lumbar spine and longer digits of the forelimbs that allow for short, rapid pursuits like in some extant cats. Thus, P. ulta may have filled a similar niche as cat-like carnivores but would have been more restricted in locomotion. Regarding the period between the extinction of oxyaenids and the first appearance of cat-like carnivores in North America by approximately 43 Ma before the diversification of crown-group felids, the function of oxyaenid postcranial elements needs to be resolved to completely compare their ecological role with cat-like forms. I made observations and measurements on the postcrania of a Patriofelis ulta from a nearly complete specimen (UMNH 550), as a representative oxyaenid to assess locomotor specializations in oxyaenids in comparison with felids.

KOSCH, Jens C., NC State University, Raleigh, NC, United States of America; ZANNO, Lindsay E., North Carolina Museum of Natural Sciences, Raleigh, NC, United States of America

The teeth of diplodocine sauropods are often deemed undiagnostic to species or genus level. To test this hypothesis we conducted morphometric studies on the teeth of three diplodocine specimens (likely representing at least two species, one including a hypothesized juvenile) and two outgroup sauropod taxa (Camarasaurus lentus and material assigned to Brachiosaurus sp.) from the Late Jurassic Morrison Formation of North America, and performed principal component (PCA) and Linear discriminant analyses (LDA) of the data. We measured all available teeth within each specimen, capturing the teeth in a named dataset for each otu. We used a range of analytical tools to describe the teeth including dental morphometric data, and analyses on a combined dataset. PCA of these same taxa using only cranial morphometric data related to the feeding apparatus were unable to significantly discriminate between operational taxonomic units (OTUs) except for the diplodocine USNM 2672. Due to the smaller sample size for the cranial values, we caution against reading strong failure of cranial morphometrics. Greatest differentiation between OTUs was achieved with a combination of dental and cranial morphometric data. With this dataset all diplodocines (USNM 2672, CM 11161, CM 11255) emerged as significantly different from each other and the macronarians, indicating that cranial dental morphometric data was a key contributor to the differentiation observed. Dental measurements are able to differentiate between diplodocines, and we advise future research on sauropod feeding ecology and evolution to include dental morphometric data (even capturing variation within the tooth row), in addition to cranial characters to improve ontogenetic, phylogenetic, and ecological signal related to the feeding apparatus.

The Anthropocene is an epoch defined by accelerated environmental changes driven by humans. These changes have a substantial impact upon all aspects of ecosystem function in the Anthropocene, and several clausilid species. New data from Beipiaosaurus inexpectus, a feathered therizinosaur from the Early Cretaceous, to assess whether the function of oxyaenid postcranial elements needs to be resolved to completely compare their ecological role with cat-like forms. I made observations and measurements on the postcrania of a Patriofelis ulta from a nearly complete specimen (UMNH 550), as a representative oxyaenid to assess locomotor specializations in oxyaenids in comparison with felids.

Herrell, Anthony, UMR 7179 - CNRS/MNHN, Paris, France; Cornette, Raphael, UMR 7205 - CNRS/ISYEB, Paris, France

WHAT CAN MORPHOLOGICAL CHANGES THROUGH TIME TELL US ABOUT DIET & HUMAN-DRIVEN HABITAT CHANGES? THE CASE OF THE ETRUSCAN SHREW IN CORSICA

KOUVARI, Miranta, University College London, London, London, United Kingdom; HERREL, Anthony, UMR 7179 - CNRS/MNHN, Paris, France; CORNETTE, Raphael, UMR 7205 - CNRS/ISYEB, Paris, France

The Anthropicocene is an epoch defined by accelerated environmental changes driven by humans. These changes have a substantial impact upon all aspects of living organisms worldwide, including their morphology. Understanding...
the mechanisms behind such changes is essential for predicting and preventing future effects on organisms. We focus on the microanatomical assemblages of a high-resolution stratigraphic sequence of 12 layers from the French island Corsica, covering approximately 600 years (14th–19th century AD) of intensified anthropisation. More specifically, we focus on Suncus etruscus, the smallest and most abundant shrew of these assemblages. We use 2D geometric morphometrics to study the shrew’s mandible shape through time and evaluate shape differences between stratigraphic layers by calculating Euclidian distances. We also calculate the Mechanical Potential (MP) of the two primary masticatory muscles. For both muscles, we use simple biomechanical models that already exist in the literature and introduce new enhanced models. We perform a Procrustes ANOVA, Pearson’s correlations and regressions to test the relation between shape, size and MP. We also study the integration patterns (if and how the shapes of different anatomical parts or modules co-evolve). We do this for the two modules of the mandible: the body and rami. We then test whether there is a relationship between shape and MP, and with changes in vegetation and human-activity through time. The distance tree shows a distinction of layers that correspond to different vegetation and anthropic conditions. The Procrustes ANOVA shows that morphological changes had functional consequences, with 6.5% of shape variability explained by MP of the temporalis, and 4.2% from MP of the masseter. The negative statistical correlation between the MP’s of those muscles, as well as their relation with vegetation and anthropic changes (shown by the regression results), suggest rapid changes in the shrew’s diet over time. We also find strong integration in our sample; however, we find similar integration patterns in layers of different environmental and human conditions. This suggests that integration is not a good indicator of rapid environmental changes and/or human impact, at least in this instance. It remains to be shown whether integration could be an indicator of longer-term environmental changes related to human activity, and whether the morphological changes found in this study are the result of natural selection or of phenotypic plasticity of the shrew mandible.

Grant Information:
We would like to thank LabEx (Diversités Biologiques et Culturelles) that funded this research internship.

Romer Prize Session (Thursday, October 10, 2019, 8:45 AM)

MUSCLE RECONSTRUCTIONS AND HUMERUS AND FEMUR
FINITE ELEMENT ANALYSES OF CRYPTOCILDUS EURYMERUS
(PLESIOSAURIA) SUPPORT UNDERWATER FLIGHT AND
FLIPPER TWISTING

KRAHL, Anna, RUB and University of Bonn, Bonchum, Germany

Plesiosaurs (Sauropterygia) are secondarily aquatic diapsids. They evolved, uniquely amongst Tetrapods, a locomotor apparatus that employed two pairs of hydrofoil flippers. However, whether plesiosaurus rowed, flew underwater, or combined both locomotory styles remains debated. Tetrapod long bones experience temporary bending, compressional, and torsional loads, but superposition of all cases shows that in tetrapods bones are loaded mostly in compressive stress. Thus, hypothetically muscle attachment surfaces and muscle lines of action (MLA) can be tested by optimizing for minimal bending and homogenous compressive stress in finite element analysis (FEA). This approach was applied to the forelimb and hindlimb of the Middle Jurassic plesiosaur Cryptoclidus eurymerus in order to investigate locomotion in plesiosaurs. First, Cryptoclidus foreflipper and hindflipper musculature was reconstructed using the extant phylogenetic bracket. Second, results were refined by comparison to recent functional analogues, including dissection of cheloniid humerus muscles. Functional analogues inform on potential muscle reductions in the distal fore- and hindfippers and on crucial muscle wrappings. Third, muscle lines of action (MLA) were obtained for all reconstructed muscles by spanning threads along the Cryptoclidus skeleton. Fourth, total muscle length changes between maximum flipper elevation and depression were measured for all gano- and acutabelum-spanning muscles. Fifth, MLA were implemented in finite element humerus and femur models, muscle forces were stochastically approximated, and compressive stress distribution was computed in ANSYS to test two load cases, upstroke and downstroke, describing an underwater flight limb cycle for each bone. A homogenous compressive stress distribution was obtained after a muscle-driven flipper twisting mechanism was reconstructed and those extensors and flexors arising from humerus and femur that contribute to flipper twisting were implemented in the finite element models. FEA model muscle forces are highest in humeral and femoral depressors and elevators indicating plesiosaurs flew underwater rather than rowed. High humeral extensor and flexor forces corroborate the flipper twisting mechanism necessary for underwater flight which had been predicted by hydrodynamic studies.

Grant Information:
This study was funded by DFG grant (W1138/9-1).

Regular Poster Session III (Friday, October 11, 2019, 4:15 - 6:15 PM)

DIETARY RECONSTRUCTION OF PLEISTOCENE DEER CERVUS ASTYLODON USING DENTAL MICROWEAR TEXTURE ANALYSIS

KUBO, Mugino O., The University of Tokyo, Chiba, Japan; FUJITA, Masaki, National Museum of Nature and Science, Ibaraki, Japan

Microwear is microscopic scars left on tooth surface during mastication. Because microwear reflects physical property of food eaten by animals, it has been used for dietary reconstruction of extinct animals. In the present study, we investigated tooth microwear of extinct deer Cervus astylodon, excavated from Late Pleistocene archaeological sites of the Okinawa Island. C. astylodon is estimated to have migrated into the Okinawa Island during the Early Pleistocene and became extinct at the end of the Late Pleistocene. This species is also known as a representative island dwarf, with the body size is estimated to be ca. 15kg. In order to examine its evolution on islands and the causes of extinction, paleoecological reconstruction of C. astylodon has been conducted. We applied three-dimensional surface texture analysis to evaluate microwear features quantitatively. By analyzing 300 individual aika deer (Cervus nippon) from 14 populations of Japan with quantitative dietary data, we found significant correlations between surface texture parameters and diet (proportion of graminoids in diet). Deer consuming a greater amount of graminoids showed rougher tooth surfaces than those consuming tree browses, because graminoid leaves contain a significant amount of silica, which abrades tooth surface. From the regression equation of surface roughness parameter and percentage of graminoids in diet, we estimated that C. astylodon might have consumed graminoids approximately 40-60% of their total diet. The current results were concordant with the previous stable carbon isotope analysis indicating C. astylodon was C3 plant feeder, but additionally clarified that they were not pure C3 browser but mixed feeder.

Grant Information:
This study was partially supported by JSPS KAKENHI (Grant No. JP16K18615 to MOK).

Technical Session XVII (Saturday, October 12, 2019, 12:00 PM)

BIOGEOGRAPHICAL NETWORK ANALYSIS OF CRETACEOUS NON-AVIAN DINOSAURS AND BIOGEOGRAPHICAL CONNECTIONS OF AUSTRALIA TO OTHER CONTINENTS

KUBO, Tai, The University of Tokyo, Tokyo, Japan

A biogeographical network of Cretaceous dinosaurs was constructed using a new method that utilizes phylogenetic relationship. This method estimates a biogeographical region of all internal nodes of a given phylogeny based on biogeographical information of the terminal taxa using ancestral state reconstruction via maximum parsimony. Then, each sister relationship in the phylogenetic tree is converted to an edge in the biogeographical network. For this presentation, continents were set as biogeographical regions and the phylogeny of dinosaur was analysed with its internal nodes which estimated age were within the Cretaceous period. The biogeographical regions were grouped using community detection algorithms that were used to partition networks. The dinosaur network that utilize all Cretaceous internal nodes was partitioned into three groups of continents: (1) North America, Asia, and Australia; (2) Europe and Africa; (3) India, Madagascar, and South America. When Early and Late Cretaceous dinosaurs were analysed separately, the dinosaur networks were divided into (1) North America, Asia, and Australia; and (2) Europe, Africa, India, and South America for the Early Cretaceous and (1) North America, Asia, and Europe; (2) India, Madagascar, and South America for the Late Cretaceous. Surprisingly, Australia was grouped with Laurasian continents, that may be due to small number of Australian species included in the analysis, namely Weewarrasaurus, Australovenator, and Kuhnarrasaurus and many plesiomorphic features retained in these taxa that placed them as a sister taxon of Laurasian taxa. Biogeographical relationship of Australia with other continents during the Cretaceous period was further investigated by adding more Australian dinosaur taxa, such as Qantassaurus, Sevumaurus, Diamantinasaurus and Rheostraurus, to the phylogenetic network and importance of finding new Australian taxa in understanding biogeography is discussed.

Grant Information:
This study was supported by JSPS KAKENHI grant number 17K14411.
Technical Session III (Wednesday, October 9, 2019, 2:30 PM)

**BURIED PRIDE: MULTIPLE INDIVIDUALS RECOVERED FROM SINGLE FOSSIL DEPOSIT, BOLT’S FARM, SOUTH AFRICA**

KUHN, Brian F., University of Johannesburg, Johannesburg, South Africa; SALESA, Manuel J., Museo Nacional de Ciencias Naturales, Madrid, Spain; ANTON, Mauricio, Museo Nacional de Ciencias Naturales, Madrid, Spain; ARGANT, Alain, Aix Marseille Univ, CNRS, Minist Culture, LAMPEA, Aix-en-Provence, France; KGASI, Lazarus, Ditsong National Museum of Natural History, Pretoria, South Africa; GOMMERY, Dominique, Sorbonne Université, Paris, France

Panthera fossils in the South African context are rare. Where they have been recovered, they tend to be isolated teeth, cranial elements or individual post cranial bones. Large deposits of Panthera fossils have been reported from sites across the northern hemisphere and have been attributed to cave lion (*Panthera spelaea*) in Europe, the Urals, the Caucasus and Siberia; and Panthera atrox in North America. Recent discoveries at the Bridge Cave loci of the Bolt’s Farm Karst System, Cradle of Humankind, South Africa, have yielded an unprecedented number of Pantherine fossils. To date more than 1300 fossils have been recovered from a deposit approximately 1.5 meters across, half a meter high and half a meter deep. Of these 1300+ fossils, 507 have been attributed to Panthera. Nearly every bone in the skeleton has been identified and we can say with confidence that there are at least seven individuals. Many of the post cranial remains are extremely large, suggesting that at least one of the individuals may have been a male, and well outside the size realm of modern Panthera leo. The presence of juvenile remains suggests that we may have an example of a fossil lion pride in a single depositional event. Other morphological variants suggest the possibility that we have identified a new species or sub-species of Panthera. The presence of *Metriosphoerus modestus* as well as Metriosphoerus andrewsi indicates an age of approximately 1.8 million years.

Grant Information:
LIA 1041, CNRS-NRF and the MPSA (Mission Paléonthropologique Franco-Sud-Africaine)

Technical Session XV (Saturday, October 12, 2019, 11:15 AM)

**MORE THAN ONE WAY TO BE A BOSS: HISTOLOGICAL PERSPECTIVES ON CRANIAL BOSS DEVELOPMENT AND ITS EFFECT ON SUTURE MORPHOLOGIES**

KULIK, Zoe T., University of Washington, WA, United States of America; MARILAO, Lianna M., Seattle, WA, United States of America; SIDOR, Christian A., Seattle, WA, United States of America

Cranial bosses, or elaborately thickened regions of the skull, convergently evolved in several amniote clades including dinosaurs, basilarchosauriforms, and mammal-like reptiles. Thickened domes encompassing most of the skull roof typify b extremely thickened skulls, whereas other therapsid clades include dicyodonts and therocephalians sometimes developed more restricted bony protruberances on the nasal or maxilla. To begin assessing differences in the tissue architecture and development of cranial bosses, we histologically sampled thickened cranial elements in **Mneme** and **Oudenodon** (Dicyodontia). We also compared the pachyostotic, or unusually thickened tissue from these skulls to similar regions of the nonpachyostosed skulls of a gorgonopsian and dicynodont. Our study indicates that digging behaviors are ancestral for taeniodonts and to test changes across phylogeny. Qualitatively, most taeniodonts, including *Oudenodon*, possess indicators of digging, i.e., a well-developed deltopectoral breast and broad distal end of the humerus for increasing flexion, pronation and supination, a long olecranon process of the ulna and enlarged manual unguals. Then we conducted quantitative multivariate analyses (linear discriminant analysis), using 9 forelimb linear measurements and 29 tarsal ones, comparing taeniodonts to a suite of extant mammals with known locomotor mode and to test changes across phylogeny. Onychodectes are placed as key basal taxa outside the clade of the more robust derived taxa (*Wortmania*, *Ectogonus*, *Pitcototherium*, *Stylinodon*). We then assessed postcranial bones to determine functional modes for taeniodonts and to test changes across phylogeny. We conducted a phylogenetic analysis by applying parsimony and Bayesian techniques to a dataset of characters gathered from extensive observation of new specimens. We found limited support for the conroycyt-stylochondont division and the genera *Conoryctes* and *Onychodectes* are placed as key basal taxa outside the clade of the more robust derived taxa (*Wortmania*, *Ectogonus*, *Pitcototherium*, *Stylinodon*). We then assessed postcranial bones to determine functional modes for taeniodonts and to test changes across phylogeny. Qualitatively, most taeniodonts, including *Oudenodon*, possess indicators of digging, i.e., a well-developed deltopectoral breast and broad distal end of the humerus for increasing flexion, pronation and supination, a long olecranon process of the ulna and enlarged manual unguals. Then we conducted quantitative multivariate analyses (linear discriminant analysis), using 9 forelimb linear measurements and 29 tarsal ones, comparing taeniodonts to a suite of extant mammals with known locomotor mode and to test changes across phylogeny.
clade (e.g., the African Kryptops palatinus and Rugops primus) are known from much less complete material. Consequently, the early evolutionary history of Abelsauridae remains poorly understood. Here we report a new taxon of medium-sized (body length ~5 m) basal abelisaurid collected from an exposure of the lowermost Upper Cretaceous (Cenomanian) Candeleros Formation in an area known as Aguada Pichana near the town of Adolfo in Neuquén Province, northern Patagonia, Argentina. The new form is known from two individuals, one of which is represented by a largely complete, partially articulated skeleton (including much of an articulated skull and multiple teeth plus dorsal, sacral, and caudal vertebrae, dorsal ribs, hemal arches, a scapula, the forelimb lacking the manus, the pelvis, and several hind limb elements); the second individual is known only from a partial skull (consisting of the maxilla, lateral, jugal, quadrate, jugal, quadrate, pterygoid, ectopterygoid, palatine, and denticy with teeth). Notable osteological features include: (1) maxilla with 14 tooth positions (as in Carnotaurus and some generically unidentified abelisaurids but 3–5 fewer than in Rugops, Skorpiovenator, and Majungasaurus); (2) lacrimal with prominent anterior process; (3) postorbital with "inflated" dorsal terminus and suborbital Rang; (4) anterior caudal transverse processes with well-developed anterior projection at distal end; (5) humerus and metatarsals proportionally slender, recalling those of non-abelisaurid abelisaurids; and (6) radius and ulna ~34% length of humerus (proportionally longer than in Aucasaurus, Carnotaurus, and Majungasaurus). Phylegetic analysis using two independent datasets recovers the new Candeleros form as a basal (i.e., non-brachyochran, non-majungasaurine) abelisaurid. As such, the new taxon is herein regarded as the earliest-branching abelisaurid that is known from the greater part of the skeleton.

Technical Session I (Wednesday, October 9, 2019, 8:45 AM)

EARLY DISPERSAL FOR QUADRUPEDAL CETACEANS: AN AMPHIBIOUS WHALE FROM THE MIDDLE EOCENE OF THE SOUTHEASTERN PACIFIC

LAMBERT, Olivier, Royal Belgian Institute of Natural Sciences, Brussels, Belgium; BIANUCCI, Giovanni, Università di Pisa, Pisa, Italy; SALAS-GISMONDI, Rodolfo, Universidad Peruana Cayetano Heredia, Lima, Peru; DI CELMA, Claudio, Università di Camerino, Camerino, Italy; STEURBAUT, Etienne, Royal Belgian Institute of Natural Sciences, Brussels, Belgium; BERNABEU, Mario, Museo de Historia Natural-UNMSM, Lima, Peru; DE MUIZON, Christian, Museum national d'Histoire Naturelle, Paris, France

Cetaceans originated in south Asia more than 50 Ma (early Eocene), from a small, four-limbed artiodactyl ancestor. Amphibious whales gradually dispersed westward across North Africa, eventually reaching North America before the end of the Lutetian (41.2 Ma). However, because the fossil record on both sides of the Atlantic is fragmentary, when, through which pathway, and under which locomotion abilities these early whales made it to the New World remains debated. Marine deposits dated to 42.6 Ma (Lutetian) from the locality of Playa Media Lanza (Pisco Basin, coastal Peru) yielded the associated skeleton of a new protocetid cetacean, including mandibles, teeth, vertebrae, scapulae, pelvis, and many fore- and hind limb elements. The study of this unique material led to the description of a new genus and species Persoggetto pacificus. It constitutes the first indisputable protocetid whale skeleton described from the whole Pacific Ocean and Southern Hemisphere, possibly the geologically oldest from the Americas, and the most complete outside Indo-Pacific. Fused sacral vertebrae, the pelvis being firmly attached to the sacrum, an insertion fossa for the round ligament on the femur, fore- and hind limb proportions being roughly similar to geologically older quadrupedal whales from Indo-Pacific, and the retention of small hooves with a flat anterovertebral tip at fingers and toes indicate that Persoggetto was still capable of standing and even walking on land. Caudal vertebrae display bifurcated and antero-posteriorly expanded transverse processes, like those of semiaquatic mammals (e.g., marine sloth Thalassocetus, beavers, and otters). Although this feature suggests a more significant contribution of the tail during swimming (lift-based propulsion) than in geologically older protocetids, the large, most likely webbed feet bearing long toes indicate that strokes from hind limbs may also have contributed to underwater locomotion (drag-based propulsion), as in otters.

Sharing similarities with some western African protocetids, this new taxon from the Lutetian of the southeastern Pacific further supports the hypothesis that early quadrupedal whales crossed the South Atlantic from Africa to South America, and nearly attained a circum-equatorial distribution with a combination of terrestrial and aquatic locomotion abilities less than 10 million years after their origin in south Asia. Assisted by the paleo-South Equatorial Current, this westward oceanic migration was followed by a northward dispersal towards higher North American latitudes.

Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM)

ON THE HISTOLOGY AND DEVELOPMENT OF DINOSAURIAN POST-CRANIAL SKELETAL PNEUMATICS

LAMBERTZ, Markus, Rheinische Friedrich-Wilhelms-Universität Bonn, Bonn, Germany

At least since the 18th century it is known that divertiola of the air sacs – bellows-like protrusions of the lungs – penetrate and invade the avian skeleton, a process which is referred to as pneumatization. Similarly, also the morphological diversity of this post-cranial skeletal pneumaticity is relatively well understood on a comparative level. This, in fact, even extends to numerous non-avian dinosaurs, many of which also possessed pneumatized bones. Given the apparent functional importance and evolutionary significance of this trait – not only for extant birds, but rather for at least the entire lineage of saurischian dinosaurs – it is astonishing how little is known about the underlying mechanisms of pneumatization. Only very recent histological studies, for instance, revealed that pneumatized bones exhibit a characteristic osteogenic tissue. This study examines whether pneumaticity can be considered a synapomorphy characterizing the derived lineage of aves; and whether the post-cranial skeleton is homologous to the avian air sacs. Furthermore, we investigate the osteological features of the pneumatic system and their development and do a histological analysis of the pneumatic structures of the post-cranial skeleton of the basal non-avian theropod Carnotaurus and some more derived theropods. A preliminary result is the finding that pneumaticity is present in other basal non-avian theropods and is present in the post-cranial skeleton a similar way in different theropod clades. This indicates that pneumatization is a synapomorphy characterizing the derived lineage of birds and the overall post-cranial skeleton of non-avian theropods. As this is a preliminary study, further analyses are needed to confirm this hypothesis.

Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)

A RE-EVALUATION OF ‘FURO’ MICROLEPIDOTES (NEOPTERYGII, HALECOMORPH) FROM THE UPPER JURASSIC SOLNHOFEN ARCHIPELAGO OF GERMANY

LANE, Jennifer A., American Museum of Natural History, New York, NY, United States of America; EBERT, Martin, Jura Museum Eichstaett, Eichstaett, Germany; SCHAWAROCH, Valerie, Baruch College, City University of New York, New York, NY, United States of America

The extinct halecomorph fish genus Furo has long been recognized as a ‘wastebasket taxon’ into which a number of unrelated species of uncertain taxonomic and phylogenetic affinities have been thrown. This has become especially problematic among ‘Furo’ from the Upper Jurassic plattenkalk regions of Germany (Solnhofen, Nyuplingen) and France (Cerin), which include ‘F.’ longiserratus, ‘F.’ latimana, ‘F.’ angustus, ‘F.’ aldingeri, ‘F.’ microlepidotes, and Ophiopsis (formerly Furo) muenteri. Of these, ‘Furo’ microlepidotes stands out as one of those most morphologically distinct from the type species Furo orthostomus from the Lower Jurassic of southeastern England. Preliminary results appear to confirm speculation by previous authors that ‘Furo’ microlepidotes is a more likely “wastebasket taxon” than other Caturidae. This study was supported by Volkswagen Foundation grant 1/84 636 and by SYNTHESES grant GB-TAF-950.

Grant Information: This study was supported by Volkswagen Foundation grant 1/84 636 and by SYNTHESES grant GB-TAF-950.
Landmark based 3D geometric morphometrics have been widely applied in analyses of skeletal morphological variation, with recent analyses successfully expanding their use to virtually constructed endocasts. This study examines endocranial shape variation within Euarchontoglires. Twenty-seven landmarks were captured for virtual endocasts produced from X-ray CT data for 130 extant members of Euarchontoglires: Scandentia (n = 14), Dermoptera (n = 12), Primates (n = 25), Didelphimorphia (n = 10), and Rodentia (n = 67) and two primitive fossil primates (Microsyops annectens, Ignacius graybullianus). Principal Components Analyses on Procrustes shape variables indicate that phylogeny plays a major role in euarchontognath endocranial shape variation. Principal Component (PC) 1 represents variation in the relative size of the neocortex and olfactory bulbs, and the degree of flexion of the endocast, with taxa at one extreme of this axis having a large neocortex, small olfactory bulbs, and a more flexed endocranium, and taxa on the other extreme having a small neocortex and a less flexed endocranium. Within this sample, Primates plot in a distinct morphospace while Dermoptera, Scandentia, Lepidoptra, and Rodentia generally overlap. A subordinal pattern is identifiable within Primates across PC1, as the highly encephalized haplorrhines group near the extreme margin of this axis while strepsirellines plot near the centre, closer to the non-primates in the analysis. Principal Component 2 is associated with variation in the shape of the olfactory bulbs and the neocortex, with taxa at one extreme having short, narrow olfactory bulbs, and a maximum neocortical height located rostrally, and taxa on the other extreme having longer, wider olfactory bulbs, and a maximum neocortical height located more caudally. All orders overlap across PC2. The primitive fossil primates M. annectens and I. graybullianus plot at the extreme of PC1, on the opposite end of that axis from the haplorrhine group near the extreme margin of this axis while strepsirellines plot near the centre, closer to the non-primates in the analysis. Principal Component 2 is associated with variation in the shape of the olfactory bulbs and the neocortex, with taxa at one extreme having short, narrow olfactory bulbs, and a maximum neocortical height located rostrally, and taxa on the other extreme having longer, wider olfactory bulbs, and a maximum neocortical height located more caudally. All orders overlap across PC2. The primitive fossil primates M. annectens and I. graybullianus plot at the extreme of PC1, on the opposite end of that axis from the haplorrhine primates. This is likely related to their shallow neocortices relative to paleocortices, and large olfactory bulbs, which is consistent with previous inferences about the importance of neocortical expansion and retraction in olfaction in primate brain evolution. This analysis provides a framework that can be used to identify morphological commonalities within Euarchontognathes to provide an approximation of what is primitive for the group, and to explore variation in both evolutionary and ecological contexts.

Grant Information:
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Technical Session XVII (Saturday, October 12, 2019, 8:45 AM)
A NEW DESERT-DWELLING NOASAURINE THEROPOD FROM THE CAIUA GROUP, CRETACEOUS OF SOUTH BRAZIL

LANGER, Max C., Ribeirão Preto, Brazil; MARTINS, Neurides, Cruzeiro do Oeste, Brazil; MANZIG, Paulo, Curitiba, Brazil; FERREIRA, Gabriel, Ribeirão Preto, Brazil; MARSLA, Julio, Ribeirão Preto, Brazil; FORTES, Edison, Maringá, Brazil; VIDAL, Luciano, Rio de Janeiro, Brazil; LIMA, Rosana, Maringá, Brazil; SANT’ANA, Lucas, Maringá, Brazil; LORENÇATO, Rosangela, Cruzeiro do Oeste, Brazil; EZCURRA, Martin, Buenos Aires, Argentina

Noasaurines form an enigmatic group of small theropod dinosaurs known from the Late Cretaceous of Gondwana. They are relatively rare, with notable records only from Argentina and Madagascar, and more incomplete remains reported for Brazil, India, and continental Africa. In south-central Brazil, the Bauru Basin has yielded a rich fauna of terrestrial tetrapods, most of which is known from the fluvial deposits of the Bauru Group. The main aeolian deposits of the Caíua Group, on the contrary, bear a scarce fossil record composed of rare lizards, a small neocortex, and very incomplete remains of a small, enigmatic theropod from the Caíua Group, which also represents the best-preserved theropod so far recovered from the entire Bauru Basin. The identified skeletal parts (vertebrae, gastralia, limbs, and scarce cranial elements) show that the new taxon was just over 1 m long, with unusual allometric traits among theropods. Metatarsals II and IV have very lateromedially compressed shafts, as are the blade-like ungual phalanges of the respective digits. This implies that the new dinosaur could have been functionally monodactyl, with a main central weight-bearing digit, flanked by neighboring elements positioned very close to digit III or even held free of the ground. Such anatomical adaptation is formerly unrecognized among archosaurs, but was previously inferred from footprint discoveries during the 1970s in the same beds that yielded the new dinosaur. A phylogenetic analysis nests the new taxon within Noasaurinae, which is unresolved because of the multiple alternative positions that Noasaurinae clade can take. The exclusion of that taxon results in positioning the new dinosaur as the sister-taxon of the Argentinean Velociraptor unicus.
presence of m1 teeth, the presence of m2 teeth, and the eruption of permanent tusks; stage four by the removal of dp4 teeth, the removal of m3 teeth, and the fusion of the epiphyses of the proximal end of the ulna, an d the distal end of the humerus, proximal end of the tibia, and distal end of the tibia; stage five by presence of m3 teeth, and the fusion of the epiphyses of the distal end of the tusk; stage four by the removal of dp4 teeth, the removal of m1 teeth, the presence of m2 teeth, and the eruption of permanent teeth and north American theropod biogeography.

LARSON, Derek W., Philip J. Currie Dinosaur Museum, Grande Prairie, AB, Canada; BRINK, Kirstin, University of British Columbia, Vancouver, BC, Canada

The St. Mary River Formation at the Scabby Butte locality is significant in being one of three formations preserving latest Campanian to Early Maastrichtian terrestrial vertebrate assemblages in Canada. Since the initial description of the Scabby Butte assemblage, new material has been collected from this locality, and a greater understanding of the systematics of theropod teeth in North America is now available for a redescription of the material and a revision of the theropod taxa present in the assemblage. To identify the teeth, comparisons were made to other well-sampled small theropod tooth assemblages in Alberta. Linear discriminant analysis of small theropod teeth from the Horseshoe Canyon and Dinosaur Park formations show that teeth differ morphologically between the units, with varying degrees of quantitative morphological overlap, indicating that isolated teeth can be identified in some instances. Morphologic comparisons between these units with the specimens from the St. Mary River (in southern Alberta) and Wapiti (in northern Alberta) formations show notable biogeographic differences between species present. In both the troodontid and dromaeosaurine comparisons, the St. Mary River Formation theropod teeth were consistent with those in the Horseshoe Canyon Formation, likely Albertavenerator carruici and an unnamed dromaeosaur. However, both saurornitholestine and avian teeth from the St. Mary River Formation were consistent with teeth from the younger Dinosaur Park Formation rather than the Horseshoe Canyon Formation, representing Saurornitholestes rather than Atrociraptor and bird teeth not present in the Horseshoe Canyon Formation. The Wapiti Formation teeth, in contrast, were entirely consistent with the penecontemporaneous Horseshoe Canyon Formation. This suggests diachronous species turnover of small theropod dinosaurs in the latest Campanian of western North America, with some of these taxa represented in assemblages throughout the Cretaceous.

Regular Poster Session I (Wednesday, October 9, 2019, 4:15 - 6:15 PM)

OBSERVATIONS ON THE MESOZOIC CHIMAEROID, ELASMODECTES NEWTON 1878


The purpose of this study is to elucidate the morphology and soft tissue anatomy of the Mesozoic chimaeroid, Elasmodectes; a genus originally raised for E. willettii from the Cenomanian of southern Britain. Since the original description, a total of 7 species have since been identified, ranging in age from the Aalenian (Middle Jurassic) to Maasrichtian (latest Cretaceous). Elasmodectes is mostly known from isolated cutting toothplates and incomplete specimens with calcified cartilage and dorsal fin spines. However, complete and fully articulated specimens are recorded from the Late Jurassic of Eichstätt (Germany) and Late Cretaceous of Jebel Tsfelat (Morocco). Around 20 holomorphic species of Elasmodectes are known, but two exceptionally well-preserved specimens, E. avitus LF 2322, housed in the Lauer Foundation Collection (Chicago, U.S.A.) and E. willettii, NHMUK PV P73270 (Natural History Museum, London, U.K.) are the focus of the present study and show soft tissue preservation. The former is of interest since it appears to be a rare male individual. The latter is the only holomorphic chimaeroid so far recorded from Africa.

Both species are known from anoxic deposits which have allowed outlines, cartilages and soft tissue preservation. From these two specimens, it is obvious that Elasmodectes possessed a fusiform body outline, with a single characteristic fin spine supporting the dorsal fin, and long median fins. The tail is homocercal with expanded dorsal and ventral lobes, in contrast to the long, whip-like condition in recent genera. The sensory canal system is represented by articulated lengths of semi-circular cartilage rings and circular cartilages are present anterior to the notochord sheath. Elements of the musculature are present in both specimens; phosphatised representations of myotomic muscle fibre blocks, arranged in a zig-zag pattern, can be clearly distinguished, as can occasional parts of the dorsolateralis musculature. The sectorial dentition comprises paired vomerine tooth plates, together with labio-lingually compressed mandibular and palatine tooth plates with beaded tritores along the crest of the occlusal surface. The frontal tenaculum in E. avitus is relatively long, compared to those in Recent chimaeroids, with a spatulate proximal end and an armature of posteriorly-directed denticles distally opposite a number of frontal denticles on the head forming a “tenacular complex.” The scroll-like pelvic clasper is preceded by a triangular pre-pelvic tenaculum.

Grant Information:
RFBR 18-05-01045 (to EVP)

Education and Outreach Poster Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)


The Lauer Foundation (LF) curates and provides permanent access to the Foundation’s collections of scientifically important palaeontological specimens and provides educational outreach programs to schools (grades 2-7). The public Earth Science educational outreach programs are customized to fit the audience. The Natural History Museum, London (NHMUK) attends fossil festivals with scientific staff and volunteers where members of the general public can interact with scientists and participate in enrichment activities. Both the LF and NHMUK programs provide hands-on learning experiences to people who do not normally have access to fossil specimens or visit museums. The programs are designed to be fun and engaging but also to inform, educate and provide interaction. Their aim is to supplement and complement the educational curriculum. As people learn differently, the use of visual, auditory and tactile teaching methods are utilized. Accommodations are made to facilitate those with special educational needs and disabilities.

Both the LF and NHMUK have found that hands-on experiences and visual aids are beneficial in order to increase the comprehension of unfamiliar concepts such as stratigraphy, deep time, fossilization and index fossils. Both provide program content designed to demonstrate why scientific data is important and how it is utilized. In addition, handouts and labeled specimens help to reinforce the retention of program information. The LF and NHMUK differ in terms of student participation. The LF programs are presented primarily in schools as either a supplement to the curriculum, or as an enrichment program. Therefore, a more visually engaging, interactive experience is required to differentiate it from their regular classrooms. In contrast, NHMUK’s participants at fossil festivals chose to participate, often returning yearly and relish the opportunity to meet and talk to experts. Post activity reflections via self-critiques, reference to learning outcomes and participant feedback are utilized to measure effectiveness of the program and refine it as needed. This valuable data identifies what was learned and what they most enjoyed from the program.

Both the LF and NHMUK provide an opportunity for children and the general public to engage in an interesting, fun, interactive learning experience to improve their understanding of the importance of science and how it applies to the past, present and future of the world. Forging a connection with young people and the community is vital for support of science initiatives.
Preparers' Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)

COMPARATIVE ANALYSIS OF PARALOID B-72 AND BUTVAR B-76 DISSOLVED IN ACETONE SOLUTIONS

LAUTERS, Brian A., South Dakota School of Mines and Technology, Rapid City, SD, United States of America

Despite the incredible importance of solution adhesives and consolidants in the preparation and conservation of fossil material, very little empirical work has been done to compare the effectiveness of one brand of polymer over the other. It is currently unknown if there is an advantage to using Paraloid B-72 or Butvar B-76 polymers dissolved in acetone in any given situation. Current anecdotal knowledge holds that low viscosity, low concentration consolidants will have better penetrative and consolidative capabilities than a high concentration, high viscosity consolidant, and Paraloid has superseded the use of Butvar B-76 in many institutions. The results of this experiment should help preparators and fossil conservators choose which polymer-based solution adhesive/consolidant to use in a given situation. In order to compare the penetrative and consolidative capabilities of these two solution adhesives/consolidants, 20ml treatments of each adhesive/consolidant prepared in varying concentrations using the weight by volume method and were applied to 200ml well sorted sand samples in varying concentrations. Viscosity of each consolidant was determined by directly comparing the results of volumetric, resistivity, and diffusion measurements. After the experimental data was collected, it was analyzed using the statistical program PAST. Qualitative and quantitative data confirmed the expected results that of Paraloid B-72 in low concentrations (5, 10, and 15%) showed greater penetration and mass consolidated than Paraloid B-72 in high concentrations (40, 45, and 50%) and Butvar B76 (in 5%, 10%, and 15% solutions). Statistical analysis using Kruskal-Wallis and Dunn’s Post Hoc tests confirmed the initial results, but also showed that high concentration Paraloid B72 showed no significant difference from the Butvar B-76 test group.

Education and Outreach Poster Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)

ENGAGING THE PUBLIC WITH SMALL VERTEBRATE FOSSILS AND UTILIZING CITIZEN SCIENCE TO MAXIMISE SCIENTIFIC DISCOVERY AT CAPRICORN CAVES, CENTRAL EASTERN QUEENSLAND, AUSTRALIA

LAWRENCE, Rochelle A., Queensland Museum, Brisbane, Australia; HOCKNNULL, Scott, Queensland Museum, Brisbane, Australia

The Capricorn Caves (CC) Fossil Open Day is a paleontologically-themed citizen science event that engages the public in an authentic program of scientific exploration. This program focuses on the fossil record of The Caves region near Rockhampton, central eastern Queensland, Australia, connecting the tourism industry with scientists and the public with science. CC is the only privately owned cave system in Australia, and is positioned as a coastal gateway to Queensland’s ‘Dig the Tropic’ geo-tourism trail, linking regional communities to science-based programs. These experiences are unique because they occur in direct context of the original natural history resource, the caves. CC is also the only accessible cave system in Australia to showcase a series of fossil deposits representing different paleoenvironments, transitioning from rainforests (>350 kya) to xeric habitat (>280 kya) and into small aquatic and terrestrial fauna. The small fauna includes a probable new species of bettong (Bettongia sp.) and several dry-adapted species (e.g., Notomys sp.). Together, these new records demonstrate a diversity of small faunal species across the FRB throughout the late Quaternary that are now either locally or entirely extinct. These changes in species level diversity and paleobiogeography since the Middle Pleistocene provide additional evidence for major periods of faunal turnover and extinction in northern Australia.

Technical Session XII (Friday, October 11, 2019, 11:30 AM)

MORE THAN MIMMI: A NEW AUSTRALIAN ANKYLOSAURIAN DINOSAUR FROM THE LOWER CRETACEOUS (ALBIAN) OF QUEENSLAND, WITH IMPLICATIONS FOR UNDERSTANDING GLOBAL THYREOPHORAN DIVERSITY.

LEAHEY, Lucy G., The University of Queensland, Brisbane, Australia; MOLNAR, Ralph E., University of California, Berkeley, CA, United States of America; SALISBURY, Steven W., The University of Queensland, Brisbane, Australia

Gondwanan ankylosaurian research has been conceptually dominated by the genus Minmi. Subsequent to the description of Minmi paravereteba in 1980, all ankylosaurian material from Queensland has provisionally been placed within this genus. However, the description of the Richmond ankylosaur (formerly Minmi sp.) and the erection of Kangarharasaurus ieveri to encompass it, as well as the recent discovery of ankylosaurian material from the Upper Cretaceous part of the Winton Formation, indicates that there is more to the diversity of Queensland ankylosaurs than just Minmi. In 1994, another partial ankylosaurian skeleton was informally assigned to Minmi pending a detailed description. Collected from the Albion Tooluc Formation, northeast of Julia Creek in north-western Queensland, this specimen represents the second most complete ankylosaurian specimen from Gondwana. It comprises the axial elements of the trunk, parts of the pectoral and pelvic girdles, fore- and hindlimbs, as well as the cranial part of the tail. The preservation of the specimen is similar to the holotype of K. ieveri, in that ossified tendinous elements as well as in situ dermal elements are fossilized. Comparisons with other ankylosaurians indicate that the specimen represents a new taxon that can be distinguished from both Minmi and Kangarharasaurus based on the morphology of elements within both the body and dermal skeletons. Notably, the specimen lacks paravertebral elements. The new taxon is of comparable size to both M. paravereteba and K. ieveri, and, also in common with both the latter taxa, has a relatively simple dermal skeleton. Phylogenetic analysis indicates that like M. paravereteba and K. ieveri, the new taxon is a basal ankylosaurian.
Chromologically, it is older than *K. inexpectus* but younger than *M. paravertebrata*. Many has often been regarded as a ‘relictual’ taxon. However, evidence for a greater diversity of thyreophorans in Australia, and thus Gondwana, is not unexpected when earlier records of thyreophorans from the Lower Cretaceous (Broome trackways, WA; isolated material, VIC) and Middle Jurassic (Balgowan trackways, QLD) are considered. The discovery and description of new thyreophoran material from Australia has the potential to significantly alter our understanding of the taxonomic diversity of the continent’s dinosaurian fauna, as well as the latent diversity of Gondwanan thyreophorans with implications for understanding global thyreophoran evolution, diversity and paleobiogeography.

Regular Poster Session I (Wednesday, October 9, 2019, 4:15 - 6:15 PM) USING FOSSILS TO UNDERSTAND THE IMPACTS OF CLIMATE CHANGE ON HERPETOFAUNA IN CENTRAL TEXAS

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Relatively little is known about the magnitude of climate change’s impact on extant herpetofaunal populations over long timespans, due in part to challenges in conducting the necessary long-term ecological studies. Paleontological evidence can address the need for long-term data by extending our temporal study interval to investigate the responses of biota to climate change over long timescales. Here, I use fossils from Hall’s Cave, located on the plateau in Kerr County, Texas, to reveal changes in the herpetofauna during the late Quaternary. Hall’s Cave represents an excellent locality for studying late Quaternary biota as it has an abundant amount of fossil material, a relatively continuous stratigraphic sequence encompassing the last 20,000 years, and numerous radiocarbon dates distributed throughout the sequence. I assembled a count of the minimum and maximum number of individuals for different reptile and amphibian taxa within 5-centimeter intervals. My preliminary results show an overall correlation between the maximum and minimum abundance metrics during the last 3,500 years suggesting that the two are in accordance with one another. A correlation was found between the abundances of frogs, snakes, and lizards through time. Abundances of these taxa have a peak at 2,000 years ago, corresponding to wetter and cooler conditions as indicated by existing climatic reconstructions from other north-central Texas localities. Herpetofaunal abundances decrease after 1,500 and between 2,500-3,500 years ago, which correspond to a warmer and drier time intervals, according to published speleothem records. These preliminary results suggest that changes in herpetofaunal abundances from Hall’s Cave may reflect responses to climatic change. My ongoing research provides insights into the changes experienced by Texas’ herpetofaunas during the late Quaternary and contributes to our understanding of the impacts of climatic change on extant and fossil biota.

Colbert Prize Poster Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM) A NEW HALSZKARAPTIRINE FROM THE BARUUNGOTYOT FORMATION OF MONGOLIA: PRELIMINARY DESCRIPTION AND PHYLOGENETIC ANALYSIS

LEE, Sangjin, Seoul National University, Seoul, Korea, Republic of (South); LEE, Yang-Nam, Seoul National University, Seoul, Korea, Republic of (South); CURRIE, Philip J., University of Alberta, Edmonton, AB, Canada; SISSONS, Robin, University of Alberta, Edmonton, AB, Canada; PARK, Jin-Young, Seoul National University, Seoul, Korea, Republic of (South); KIM, Su-Hwan, Seoul National University, Seoul, Korea, Republic of (South); BARSBOLD, Rinchen, Institute of Paleontology and Geology, Mongolian Academy of Sciences, Ulaanbaatar, Mongolia; TSOGTBAATAR, Khashigjav, Institute of Paleontology and Geology, Mongolian Academy of Sciences, Ulaanbaatar, Mongolia

The Halszkaraptorine is a recently erected subfamily of the Dromaeosauridae and comprises only three known taxa from the Late Cretaceous of Mongolia. They have been interpreted as semi-aquatic animals based on extremely long necks, forelimbs possibly capable of swimming, and relatively short tails. The paleoecology of halszkaraptorines is thus different from other non-avian maniraptorans. Despite their unusual characters, however, it has been very difficult to study these dinosaurs due to their rare fossil record. In addition, only Halszkaraptor escultii is represented amongst halszkaraptorines by a nearly complete skeleton. A new halszkaraptorin specimen from the Baruungoyot Formation of Mongolia was found at Hermin Tsav during the Korea-Mongolia International Dinosaur Expedition (KID) in the southern Gobi Desert in 2008. It is a nearly complete skeleton with a skull. The specimen is only slightly smaller than the holotype of *H. escultii*. The new specimen (KID275) has synapomorphies of dromaeosaurids such as an elongate pre-antorbital part of the maxilla, cheek teeth with concave posterior margins; subparallel dorsal and ventral margins of the dentary; ginglymoid distal ends of metatarsals II and III, and a short and stout pedal phalanx II-1. It is further diagnosed as a halszkaraptorine by a long neck, horizontal zygopophyses; prominent zygodiapophyseal laminae of the proximal caudal vertebrae, and because the shaft of metacarpal III has a similar mediolateral width as that of metacarpal II. KID275 is distinguished from other halszkaraptorines by the following set of characters: premaxilla has an anteroposterior depression at the anterior end; the internal process of the premaxilla overlies the nasal, there are more than 12 premaxillary teeth, the external nares are anteroposteriorly elongate, there is a sinuous suture between the frontal and parietal, none of the cervical vertebrae have pleurocenous, each anteroposteriorly expanded proximal to the articulation with most of the length of each centrum, and the proximodistally elongate pedal phalanx IV-1 exceeds the length of pedal phalanx II-1. Our phylogenetic analysis recovered KID275 as the basalmost halszkaraptorine. Investigation of the paleobiology of KID275 will provide clues to better understand how halszkaraptorines lived and diversified.

Grant Information: The research is supported by the National Research Foundation of Korea (grant number 2016R1A2B2015012) to Yang-Nam Lee.

Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM) THE FIRST CHORISTODERAN TRACKWAY?

LEE, Yang-Nam, Seoul National University, Seoul, Korea, Republic of (South); KONG, Dal-Yong, National Research Institute of Cultural Heritage, Daejeon, Korea, Republic of (South); JUNG, Seong-Ho, National Research Institute of Cultural Heritage, Daejeon, Korea, Republic of (South)

The fossil record of choristoderes shows the highest diversity in the Early Cretaceous of eastern Asia, especially in China as well as in Japan and Mongolia, suggesting that these regions including Korea were an important center for choristodern evolution. While abundant crocodyliform tracks have been reported in the Jurassic and Cretaceous in the world, however, there is no single report thus far on the choristodern tracks. Recently, a new quadrupedal trackway with hetropody was discovered in the Daegu Formation (Albian, Early Cretaceous), Ulsan City, South Korea. It consists of nine manus-pes sets of footprints. The manus tracks are pentadactyl, digitigrade (Albian, Early Cretaceous), Ulsan City, South Korea. It consists of nine manus-pes sets of footprints. The manus tracks are pentadactyl, digitigrade and slightly recurved digits. Their length and width are 29.4 mm and 53.0 mm on average, respectively. Five manual digits are separated from the proximal base and terminating in claws. Digits I and V are opposed with more than 180° and are oriented anteromedially and posterolaterally, respectively with respect to the trackway axis. The fourth digit is the longest, being ectaxonic. All manus tracks are located medially in front of pes tracks. The pes tracks are also pentadactyl with opposed digits I and V. They are plantigrade with slender digits with claw marks. Digits III and IV imprints are much longer than digit II imprint and the digit I imprint is the shortest, being distinctly ectaxonic. There is an indication of webbing between the pedal digits. The elongate heel is oval and almost symmetrical with respect to the central axis of the foot. The average length and width of the pes footprints are 98.8 mm and 69.3 mm, respectively. There is no belly mark nor tail trace. Although seven choristoderan genera were reported in the Early Cretaceous of Asia, well-preserved hands and feet are known only in *Hyphalosaurus* and *Monjurosuchus* among them. While long-necked and fully aquatic *Hyphalosaurus* inhabited exclusively in deep water lakes, short-necked and semi-aquatic *Monjurosuchus* lived in a more shallow water ecosystem. New quadrupedal tracks are fairly well matched with foot skeletons of *Monjurosuchus* such as the hind foot much larger than the forefoot, long metatarsals, the shortest pedal digit I with similar length of digits III and IV, webbed hind feet, and the hindlimb much longer than the forelimb. In addition, the average of glenoacetabular length of the trackway is 228.8 mm, which is concordant with the body size of *Monjurosuchus* whose snout-vent length is up to 300 mm. Therefore, Ulsan new trackway could be made by a *Monjurosuchus*-like choristodern.

Grant Information: The National Research Foundation of Korea (grant number 2016R1A2B2015012)
Technical Session XX (Saturday, October 12, 2019, 1:45 PM)

USING TRABECULAR ANISOTROPY TO DETERMINE THE POTENTIAL FOR WALKING LIMBS IN A DIVERSE ARRAY OF EARLY TETRAPODS FROM BLUE BEACH, NOVA SCOTIA

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A historical explanation of the fin-to-limb transition suggested fish moving across land to get from one drying pool of water to another drove the evolution from aquatic to terrestrial lifestyles. However, it has become clear that digits likely arose well before the transition into terrestrial environments. Previous research on tetrapod morphology has focused on descriptions of external limb and cranial morphology, but few have examined microanatomy to determine how limbs could bear the animal's weight on land. Those that did studied internal bone structure focused on the midshaft profile created from a single histological slice of a long bone, which does not reflect the full extent of directional forces that may act on a bone. This study uses the entire 3D volume of trabecular bone in long bones of early tetrapods to test if bone structure reflects forces associated with aquatic or terrestrial locomotion.

Long bones remodel in response to intermittent loading; here we look specifically at how trabecular bone structurally aligns with the forces acting on the bone. Anisotropy, a measure of structural organization, is analyzed from the trabecular bone to infer the location, orientation, and potentially strength of intermittent forces from musculature or gravity. The limb bones used in this study come from Blue Beach Nova Scotia, an early Tournaisian locality with a diverse array of early tetrapod bones thought to include both aquatic and terrestrial tetrapods. We expect this diversity to include bones from aquatic to terrestrial tetrapods. We expect this diversity to include bones with low anisotropy as expected in aquatic animals, and high anisotropy as in terrestrial long bones. Bones representing all available tetrapods from this locality display low anisotropy in the trabecular region, in contrast with predictions derived from taxonomy and morphological proxys. Areas of higher organization are scattered throughout the trabecular bone closest to the compact bone layer, but these few anisotropic regions are small, suggesting that forces acting on the bone were weak and not constrained to specific areas. We conclude that a greater variety of tetrapods from the earliest Carboniferous than previously thought had limbs better adapted to an aquatic rather than terrestrial lifestyle, further supporting the idea that limbs evolved in an aquatic context for a prolonged period and the fin-to-limb transition is not contemporaneous with the water to land transition.

Grant Information:
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Regular Poster Session I (Wednesday, October 9, 2019, 4:15 - 6:15 PM)

DENTAL TOPOGRAPHIC CHANGE AND DIETARY INFERENCE IN HOMUNCULUS PATAGONICUS AMEGHINO, 1891 (MAMMALIA: PRIMATES)

LI, Peishu, Duke University, Durham, NC, United States of America, 27708; MORSE, Paul E., Duke University, Durham, NC, United States of America; KAY, Richard F., Duke University, Durham, NC, United States of America

Molar occlusal surfaces in extant primates correspond with the physical properties of the diet. Frugivores, and folivores generally have multicusps for slicing tougher foods; frugivores have multicusps with blunt cusps for better crushing and grinding performance. Dental topographic metrics are homology- and landmark-free methods that measure functionally relevant qualities of the tooth crown, such as sharpness (Dirichlet normal energy [DNE]), complexity (orientation patch count rotated [OPCR]), and relief index (RFI). These metrics are ideal for comparison between species and within clades. A recent analysis of DNE in the extant folivorous platyrrhine Ateles found that this species increases occlusal sharpness as the teeth wear, whereas sharpness was maintained but did not increase with wear in the frugivorous Ateles. This diet-specific modality of dental macrowear offers a novel pathway to inferring dietary changes in the fossil record. Homunculus patagonicus is a stem platyrrhine from the Early Miocene, high-altitude Santa Cruz Formation, Argentina. Prior analysis of shearing quotient in Homunculus suggested a mixed diet of fruit and leaves, but its heavy posterior tooth wear and large root size are more similar to extant folivorous platyrrhines. We measured DNE, OPCR, and RFI in 21 μCT-generated 3D digital models of variably-worn first and second lower molars of Homunculus, and compared them with the wear series of Ateles and Ateles. DNE, OPCR and RFI do not vary significantly between Homunculus M1 and M3 (Mann-Whitney U test p > 0.05). DNE and OPCR of unworn Homunculus molars are more similar to those of Alouatta than Ateles. However, Homunculus DNE does not change significantly with macrowear, and was statistically indistinct from the relationship between crown sharpness and wear observed in Ateles (ANCOVA p = 0.238) vs. a significant difference from that in Alouatta (ANCOVA p < 0.001). As in Ateles, OPCR of Homunculus has a significant positive linear trend with wear (p = 0.009), whereas no significant linear correlation was observed between OPCR and macrowear in Alouatta. Despite the folivore-like topography of unworn Homunculus molars, wear-induced changes in crown sharpness and complexity are more consistent with a frugivorous diet. The degree and pattern of wear observed in Homunculus is consistent with a primarily frugivorous diet with leaves as a fallback resource.

Regular Poster Session III (Friday, October 11, 2019, 4:15 - 6:15 PM)

LOCOMOTIVE IMPLICATIONS OF THE 7.4 MA HIPPARIONINE FOSSILS FROM THE MIDDLE REACHES OF THE YELLOW RIVER AND THEIR PALEO-ECOLOGICAL SIGNIFICANCE

LI, Yangfan, Northwest University, Xi'an, China; DENG, Tao, IVPP, Beijing, China; HUA, Hong, Northwest University, Xi'an, China

The Late Miocene landscape in the middle reaches of the Yellow River was divided into grassland or steppe, which was analogous to that of the African savannah. This view contradicts the mainstream recognition regarding the paleoecology of the Loess Plateau. The ecomorphology of fossil equids plays an important role in paleoecological and paleogeographical interpretations, particularly through locomotive function. The morphologies of the 7.4 Ma hipparionine fossils (Hipparion chinat) from the Lagou Fauna in northern Shaanxi reveal "pristine" features; however, the limb bones indicate that their motor abilities were adapted to an open environment. By comparing the wear of the Lagou Fauna with modern hipparionine species and further illustrate its morphological variability, as referred to the paleoecological and paleogeographical boundary of northern China, we conclude that the Lagou Fauna inhabited a temperate steppe. However, H. chinat should be a grassland dweller that was adapted to open habitat.

Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM)

SKULL REMAINS OF A SMALL FELINE (CARNIVORA, FELIDAE) FROM THE LATE MIocene DEPOSITS OF LINXIA BASIN (GANsu PROVINCE, CHINA)

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The Linxia Basin of Gansu Province, in northwest China, is notably enriched with abundant and well preserved Late Cenozoic fossil mammals. Among them, numerous materials of small felid have been discovered from the "red clay" deposits of the late Miocene Liushu Formation. After preliminary identification, at least five genera have been recognized, including large-sized Machairodus, Paramachairodus, Metallurus, medium-sized Yoshi, and small-sized Pristifelis. Here we report two almost complete skulls of caracal-sized feline from the Linxia Basin. They are attributed to Pristifelis attica (Wagner 1857) based on the size and several cranial and dental characters. While skulls, dental and postcranial elements of P. attica have often been reported from Turanian localities in Spain, Greece, Turkey and Iran, the new fossil skulls represent the first discovery of P. attica from the Linxia Basin. They provide supplementary information to this species and further illustrate its morphological variability, as referred to the presence of P2; the mesial cusp on P3 and ectostyle on P4. In addition, personal observations on other late Miocene materials previously reported as Felis sp. from China confirm the existence of P. attica in Shanxi Province. The fossil records of P. attica indicate that it is a widespread late Miocene small felid, which has an almost continuous distribution in geography, probably spread from the whole southern Europe to the eastern Asia and could inhabit various environment like the living species Felis sylvestris.

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LINDOSO, Rafael M., Federal Institute of Education, Science and Technology of Maranhão, São Luis, Brazil; MAISEY, John, American Museum of Natural History, New York, NY, United States of America; CARVALHO, Ismar D., Federal University of Rio de Janeiro, Rio de Janeiro, Brazil

In north-eastern South America, the biogeographical history of Gondwana has been directly affected by the formation of the South Atlantic and Equatorial oceans. Eustatic sea level associated to the warming ocean floor spreading during the Early Cretaceous originated a temporary epicontinental seaway in the Northeastern Brazil. Hypotheses regarding its possible route of ingress have not been consistent. However, recent palaeontological data concerning Aptian-Albian fossil fish assemblages in Brazilian Northeastern Marginal and Interior Basins (BNMIBs) have suggested a biotic relation with Tethyan ichthyofaunas. The Lower Cretaceous Santana Formation of the Ararape Basin has provided the best known fossil fish record in South America. The oldest fishes occur under brackish/hypersaline conditions but with intermittent marine connections, which is indicated by species of the genera Vincitfer, Rhacolepis, Notolepis, and Araripichthys. The fossil fishes of the Santana, Codó and Riauchuelos formations show a greater similarity to each other than to assemblages from other BNMIBs. This suggests a greater connectivity between the depositional environments dominating the Ararape, Parnaíba and São Francisco-Alagoas Basins during the Late Jurassic.

Here, we report on a new, highly non-asthenocormid pachycormid, the first occurrence in the BNMIBs. The specimen was collected from the Upper Albian Riauchuelos Formation at the Móreia do Vish Formation, Amapá State, Brazil. This fish was previously described as an elaborate gill rakered species from the Upper Jurassic of the Mühlheim quarry (Upper Jurassic, Mörnsheim Fm.), with a highly non-asthenocormid shape. In 2009, a tail ray robustispina (0.5x, although occasional discoveries had suggested that there might be something larger. Anomalous pectoral fins in the BSPG, Munich, since 1951 were >3x any recorded specimen of Leedsichthys, with a highly non-asthenocormid shape. In 2009, a tail ray specimen was found in the Mühlheim quarry (Upper Jurassic, Mörnheim Fm.), exhibiting the classic pachycormid characteristic of bifurcating without segmentation, to a length of around 90cm. 3x longest recorded for Asthenocormus (0.5x. Leedichthys). In 2015, the pit also yielded highly elaborate gill rakers more than twice the length of those commonly seen in Leedichthys, and substantially more robust. Although virtually meaningless to estimate the size of such an animal from these small components of its gill basket, it is the first evidence that the Upper Jurassic in Southern Germany may have had a significantly larger suspension-feeding pachycormid than the Middle Jurassic Leedichthys, indicating that the Plattenkalk deposits preserve even more of a diversity hotspot than previously suspected, with the apex of Mesozoic suspension-feeding unexpectedly represented in this ecosystem.

Grant Information:
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Technical Session X (Friday, October 11, 2019, 10:15 AM)

The BEAST OF MÜHLHEIM: FIRST EVIDENCE OF A SOLNHOFEN MEGAPLANKTIVORE

LISTON, Jeff, BSPG, Munich, Germany; HEYNG, Alexander, BSPG, Munich, Germany

As the first animals to successfully occupy the large (> 1 in Standard Length, SL) vertebrate suspension-feeding niche, pachycormid osteichthyans were the Mesozoic ecological forerunners of today’s cetacean (mysticetes) and chondrichthyans (Rhincodon and Cetorhinus) planktovores. At their acme in the Callovian (Middle Jurassic), suspension-feeding pachycormids were growing to sizes in excess of today’s whale sharks (Leedichthys, estimated SL 16 metres), achieving a scale of growth unequaled by subsequent osteichthyan. Until recently, the largest suspension-feeding pachycormid in the Upper Jurassic Plattenkalk fauna was the 1.9-2.3 metres long Asthenocormus, although occasional discoveries had suggested that there might be something larger. Anomalous pectoral fins in the BSPG, Munich, since 1951 were ~5x any recorded specimen of Asthenocormus (0.5x Leedichthys), with a highly non-asthenocormid shape. In 2015, the pit also yielded highly elaborate gill rakers more than twice the length of those commonly seen in Leedichthys, and substantially more robust. Although virtually meaningless to estimate the size of such an animal from these small components of its gill basket, it is the first evidence that the Upper Jurassic in Southern Germany may have had a significantly larger suspension-feeding pachycormid than the Middle Jurassic Leedichthys, indicating that the Plattenkalk deposits preserve even more of a diversity hotspot than previously suspected, with the apex of Mesozoic suspension-feeding unexpectedly represented in this ecosystem.

Grant Information:
NNSF of China (41862001), NSG of Guangxi (2017JGXNSFA198291), and State Key Laboratory of Paleobiology and Stratigraphy (173116).

Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM)

NEW TETRAPODS FROM THE SUNJIAGOU FORMATION AND SHANGSHIHEZI (UPPER SHIHHOTSE) FORMATION, SHANXI, CHINA AND ITS IMPLICATIONS

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In China, the outcrops of the Sunjiagou Formation and Shangshihezi Formation have most widespread distribution among synchronous terrestrial late Permian deposits. However, only pareiasaurs among tetrapods have been reported from the Sunjiagou Formation, and only one tetrapod fossil locality is known for the Shangshihezi Formation. Up to now, the tetrapod diversity from two formations is low, and dicynodonts, one common Permian tetrapod group, have never been reported from them. In contrast, dicynodonts are abundant and the tetrapod diversity is much higher for the Naobagou Formation, which only distributes within a small basin. In 2017, a partial pareiasaur skeleton was discovered from the upper portion of the Shangshihezi Formation at Shouyuan, Shanxi, China. In 2018, three dicynodont specimens and one pareiasaur specimen were collected from the Sunjiagou and Shangshihezi formations. These dicynodonts show closely relationship with those from the Naobagou Formation. One mandible displays some unique features among dicynodonts, such as long retroauricular process with anteroposterior length roughly equal to the height of articular, midline troclea directs postero-laterally rather than postero-medially, furthermore, one skull shows close relationship with one dicynodont species
from Laos. It supports the form of a land-bridge by the end of Permian on the eastern margin of Pangea. The current clues indicate a diverse tetrapod assemblage could be recovered from the Sunjigou Formation and Shangshibeizi Formation of Shanxi, China.

Grant Information:
National Natural Science Foundation of China (Grant No. 41572019)
Excavation Funding of Chinese Academy of Sciences

Technical Session I (Wednesday, October 9, 2019, 10:30 AM)

**BUT DID IT EAT OTHER WHALES? NEW ENAMEL MICROSTRUCTURE AND ISOTOPIC DATA ON LIVYATAN, A LARGE PHYSETEROID FROM THE ATACAMA REGION, NORTHERN CHILE**

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Livyatan was a macroraptorial extinct genus of sperm whale, with records from the Neogene of Peru, Chile and Australia. Like other Neogene-age physetheroids, Livyatan had large functional upper and lower teeth, which likely reflects a hypercarnivorous feeding style. We examined the morphology, enamel microstructure, and isotopic composition of a putative lower jaw and teeth from the Bahia Inglesa Formation, northern Chile. The subcylindrical tooth is 322 mm long and 109 mm in diameter, comparing favourably to holotype teeth from Peru. This Chilean specimen is slightly smaller than the largest of the type series teeth, which were 362 mm long. The crown is curved lingually, approximately 30 degrees from the main axis. The root apex is open and a thick cementum layer covers the root. A rugose enamel tip covers part of the crown. Enamel fragments were removed from the crown base for scanning electron microscopy (SEM) and isotopic analyses. SEM images revealed a moderately thick enamel (600 μm) with prominent Hunter-Schreger bands (HSB) throughout the whole thickness, with both open and closed prisms present. HSB are implicated in resisting and limiting enamel crack propagation, being considered a biomechanical response to increased occlusal loads sustained during feeding. The carbon and oxygen isotopic compositions of structural carbonate from enamel and dentine samples were analysed as a proxy of diet and habitat information. We observed an extremely low δ¹³C value in enamel (δ¹³C = −16.5‰), which suggests feeding at southern latitudes greater than 40°S. Based on isotopic analysis of fossil naticetes from the same rock unit, it seems unlikely the Livyatan specimen analysed here was exclusively macrophagous; however, it could have fed on mysticetes from higher latitudes. The presence of HSB in Livyatan suggests a reduction in enamel complexity in physetheroids over time, as extant sperm whales have thin, prismatic enamel that is often worn away. Further analysis considering more specimens will help elucidate the feeding ecology of these poorly known cetaceans.

Grant Information:
C Loch acknowledges a Sir Thomas Kay Sidley Research Grant

Technical Session X (Friday, October 11, 2019, 8:30 AM)

**EXCEPTIONALLY WELL-PRESERVED FISHES, INCLUDING A NEW POROLEPIFORM AND NEW ARTHRODIRINES, FROM THE LATE DEVONIAN GOGO FORMATION OF WESTERN AUSTRALIA**

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The Gogo Formation of Western Australia is renowned for its exceptional 3D preservation of both bone and soft tissue in fossil fishes that inhabited an ancient reef environment. It is also one of the most diverse vertebrate assemblages of this age (Frasnian) with over 50 species of placoderms, osteichthyans, raylike sharks and acanthodians that once inhabited the algal-stromatoporoid reef environment.

The earliest expeditions (1963, 1967) led by the British Museum of Natural History, working with Western Australian Museum and Hunterian Museum staff managed to collect about half the known taxa of Gogo fishes, and these were methodically described between 1971-1995. Field expeditions lead by the author and other Australian teams systematically collected at the sites from the early 1970s (ANU Geology, BMR, WA Museum, Museum Victoria, Curtin University teams) which added a significant number of new taxa plus better specimens of poorly described taxa, representing groups not previously known or incomplete from the initial collections.

These included the first records of complete tetrapodomorph fishes, many new lungfishes and actinopterygian taxa, and the first record of coelacanth, shark and acanthodian taxa. More significantly these later expeditions found the first evidence of well-preserved soft tissue, embryos and sexual organs in certain groups of placoderms.

Recent collecting from the site keeps yielding high quality 3D new taxa from the formation. Here we report the first occurrence of a porolepiform (Osteichthyes; Dipnomorpha, Porolepidiformes), known from relatively complete skull remains, indicating that a Glyptolepis grade taxon was present. The new specimen under CT scanning and neutron beam analysis show remarkable anatomical details of the porolepiform braincase and other cranial features.

In addition, new placoderm taxa keep being uncovered, including a new large predatory genus of arthrodire related to the earliest arthrodire group, but with well-developed pointed teeth along all gnathal plates. New smaller taxa of extant arthrodires indicate that micro-predatory niches were occupied by fishes of the reef system.

Grant Information:
ARC DP 140104161

Technical Session VI (Thursday, October 10, 2019, 8:15 AM)

**DENTAL TOPOGRAPHY ANALYSIS AND DIETARY INFERENCE OF THE MIOCENE NEOTROPICAL BAT NOTONYCTERIS MAGDALENENSIS FROM LA VENTA, COLOMBIA**

LOPEZ-AGUIRRE, Camilo, University of New South Wales, Sydney, Australia; LINK, Andres, Universidad de Los Andes, Bogota, Colombia

The fossiliferous locality of La Venta contains the richest Cenozoic vertebrate fossil community of northern South America. It includes over 70 mammals and covers a poorly-represented time span in the middle Miocene, helping to define the Lavanent South American Land Mammal Age (SLAMA).

Best known for its diverse primate community, La Venta has yielded 14 Miocene bat species, including the oldest plant-visiting bat in the world, and some of the earliest fossil evidence of extant families Phyllostomidae, Thyroptera and Noctilionidae. Notonycteris magdalenensis is an early phyllostomid that has been instrumental for phylogenetic and systematic analyses. It has been described as an early relative of the modern subfamily Phyllostominae, a group of Neotropical animalivorous and omnivorous bats. Despite its importance for the study of the evolution of Neotropical bats, the biology of N. magdalenensis remains mostly unknown.

N. magdalenensis is represented by several complete molars, providing an opportunity to study possible ecological adaptations. Using 3D computational modelling, we implemented dental topography analysis to infer the diet of N. magdalenensis. We compared the dental complexity in two lower first molars of N. magdalenensis with 19 modern phyllostomid species, covering a wide range of diets. We performed multivariate analysis based on three measures of dental complexity: Dirichlet Normal Energy (DNE), Relief Index (RFI), and Oriented Patch Count Rotated (OPCR).

Based on our sample, species with liquid diets (nectarivorous and sanguivorous) had lower DNE and OPCR values, whereas frugivorous species had lower values of RFI. Based on Principal Component Analysis (PCA), DNE and OPCR explained the highest amount of variability in our results. Our PCA separated species with different diets, with some overlap between insectivores and omnivores. Discriminant Function Analysis (LDA) better discriminated between diets, and classified both N. magdalenensis specimens as omnivorous species. Our results, coupled with previous ecological studies on other bats from La Venta, indicate a generalist phyllostomid paleocommunity with an ample morphological diversity.

Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM)

**FIRST MYOCRITIODONTIDAE (RODENTIA) FROM THE MIocene OF LEBANON**

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Recent excavations in the lacustrine Late Miocene of Lebanon resulted in the discovery of several new fossiliferous localities near the city of Zahleh. They are the first Late Miocene sites with micromammals in Lebanon and the second ones in the whole Arabian Peninsula. Several isolated molars of a Myocriniodontidae have been recovered from one of these localities. The
Myocricetodontinae are a group of rodents, which is supposed to have originated in the Middle East during the Early Miocene. Their evolutionary history, systematics and stratigraphic range are debated. The Lebanese myocricetodontine has low crowned cheek teeth. Its upper molars are characterized by a normal longitudinal crest with the posterior mure somewhat reduced, strong labial and lingual cingula surrounding the valleys, absent or incipient accessory cusps and no mesoloph. The third upper molars are somewhat reduced, strong labial and lingual cingula surrounding the valleys, well-developed labial and lingual anterolophids, labial cingula surrounding the valleys and a large posterolophid. They lack the mesolophid. The size and overall morphology of these teeth are strongly reminiscent of Mellalomys. We determine the Lebanese myocricetodontine as belonging to this primitive group. Some features, such as the presence of a single antracron on the upper molar, suggest that it does not pertain to any species of the genus already known. Mellalomys has been recorded so far from the Early and Middle Miocene of South Asia and the Middle Miocene of North Africa. The dispersal of this genus from South Asia to North Africa took place through the Levant. This extends the temporal range of this genus into the early Late Miocene.

Technical Session X (Friday, October 11, 2019, 10:30 AM)
THE ENIGMATIC AINIA ARMATA WAGNER AND ITS SIGNIFICANCE FOR ACTINOPTERYGIAN SYSTEMATICS

LOPEZ-ARBARELLO, Adriana, Ludwig-Maximilians-Universität München, Munich, Germany; SFRICO, Emilía, CICTERRA-CONICET-UNC, Córdoba, Argentina; MIRANDE, Marcos J., Fundación Miguel Lillo – UEL-CONICET-FML, San Miguel de Tucumán, Argentina

Ainia is a rare fish in the late Jurassic limestones of Europe, which has been known from some specimens from Cerin (France) and very few specimens from the Solnhofen Archipelago (Germany). The species was erected based on a complete specimen from Solnhofen with the name Lepidostus armatus Wagner, while the French material was described as Callopterus agassizi Thioliére, name that prevailed after the synonymy of the specimen from both countries. However, according to the ICZN Wagner’s species name has priority. Also, the generic name Callopterus is a non-nom nomen nudum and it was replaced by Ainia Jordan. Therefore, the correct name of the species is Ainia armata.

New specimens from Germany triggered a new anatomical and systematic study of this taxon, which is easily distinguished by its very small size, the dor sum and ventrum of the caudal peduncle not being oriented in antero dorsal to posteroventral direction like the norm.

Ainia was not a particularly agile species within the context of lagomorphs. This is consistent with the idea that Megalagus has one of the highest values for low-frequency sensitivity among the sample, suggesting that this animal was better adapted for detecting some range of low-frequency sounds.

Ainia is closer in proportional SCC size to the volcano rabbit (Romeralagus diazii), which dwells in dense zacaton grass. A level of agility for Megalagus was reconstructed as 45.2 and 12.1 decibels (dB) for low- (250 Hz) and high-frequency (32 kHz) sounds, respectively. Overall, the reconstructions for Megalagus are in the range of extant lagomorphs for both low- and high-frequency sensitivity. However, it is worth noting that Megalagus has one of the highest values for low-frequency sensitivity among the sample, suggesting that this animal was better adapted for detecting some range of low-frequency sounds.

Ainia was not a particularly agile species within the context of lagomorphs. This is consistent with the idea that Megalagus was more of a woodland dweller rather than an open-habitat runner.

Grant Information:
Supported by an NSERC discovery grant to MTS and a National Science Centre (Cracow, Poland) grant (number 2015/18/NZB/00637) to LFF.

Symposium: Quaternary Extinctions (Friday, October 11, 2019, 2:45 PM)
QUATERNARY EXTINCTION OF LARGE RAINFOREST HERBIVORES ON INDONESIA’S LARGEST ISLAND, SUMATRA

LOUYS, Julien, Griffith University, West End, Australia; ZAIM, Yahdi, Institut Teknologi Bandung, Bandung, Indonesia; SASHI, Awan, Institut Teknologi Bandung, Bandung, Indonesia; PRICE, Gilbert, University of Queensland, Redbank Plains, Australia; RIZAL, Yan, Institut Teknologi Bandung, Bandung, Indonesia; PUSPANINGRUM, Mika, Institut Teknologi Bandung, Bandung, Indonesia; TRHASCARYO, Agus, Institut Teknologi Bandung, Bandung, Indonesia; HIGGINS, Penny, University of Rochester, Rochester, NY, United States of America; ROBERTS, Patrick, Max Planck, Jena, Germany

Sumatra is the world’s sixth largest island, and Indonesia’s largest. It hosts 201 mammal species, of which nine are endemic to mainland Sumatra, fourteen to Mentawai islands, and 22 found nowhere else in Indonesia. Unlike other major islands in Southeast Asia, it records very few Quaternary extinctions. Here, we report the first globally extinct taxon from the island. Hexaprotodon, the Asian hippo, is represented by the anterior portion of a second lower molar as well as some canine fragments. These were recovered from Ngilau Gupin, a cave site in the Padang Highlands. A tapir molar from the same site has been dated to at least 45,000 years old by uranium series dating. Other than the hippo, the banteng, the buffalo, and the Javan rhino became extirpated from the island, probably sometime in the historical period. Examination of carbon and oxygen isotope values from fossil and modern large mammal communities show no significant differences in either isotope

WITHDRAWN

Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM)
FIRST VIRTUAL RECONSTRUCTION OF THE INNER EAR OF A FOSSIL RABBIT: LOCOMOTOR BEHAVIOUR AND HEARING SENSITIVITY OF MEGALAGUS TURGIDUS (EARLY OLIGOCENE OF NEBRASKA)

LOPEZ-TORRES, Sergio, Polish Academy of Sciences, Warsaw, Poland; BHAGAT, Raj, University of Toronto Scarborough, Toronto, ON, Canada; SILCOX, Mary T., University of Toronto Scarborough, Toronto, ON, Canada; FOSTOWICZ-FRELIK, Lucja, Polish Academy of Sciences, Warsaw, Poland

The inner ear can be highly informative about locomotor agility and hearing sensitivity. Having larger semicircular canals (SCCs) relative to body mass implies faster, jerkier locomotion compared to having smaller SCCs. Cochlear and oval window dimensions are associated with low- and high-frequency hearing sensitivities, respectively. In this study, agility and hearing sensitivities are reconstructed from the inner ear of the stem lagomorph Megalagus turgidus (UC 1642) from the early Oligocene of the Brule Formation of Nebraska. UC 1642 includes an almost complete cranium with both zygomatic arches largely missing, as well as some damage around the left external auditory region and lateral portion of the cranium. It preserves the right inner ear, including both the SCCs and the cochlea. The cranium was micro-CT scanned, and the ear was segmented using Avizo 9.0.1. A comparative sample of inner ear metric data taken from scanned crania of extant lagomorphs was created, including representatives of the two modern lagomorph lineages: leporids (N = 8) and ochotonids (N = 3).

The hearing sensitivities for Megalagus are reconstructed as 45.2 and 12.1 decibels (dB) for low- (250 Hz) and high-frequency (32 kHz) sounds, respectively. Overall, the reconstructions for Megalagus are in the range of extant lagomorphs for both low- and high-frequency sensitivity. However, it is worth noting that Megalagus has one of the highest values for low-frequency sensitivity among the sample, suggesting that this animal was better adapted for detecting some range of low-frequency sounds.

In sum, these data show that, by the early Oligocene, stem lagomorphs already had fundamentally rabbit-like hearing sensitivity and locomotor behaviour, even though Megalagus was not a particularly agile species within the context of lagomorphs. This is consistent with the idea that Megalagus was more of a woodland dweller rather than an open-habitat runner.

Grant Information:
Supported by an NSERC discovery grant to MTS and a National Science Centre (Cracow, Poland) grant (number 2015/18/NZB/00637) to LFF.

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LOUYS, Julien, Griffith University, West End, Australia; ZAIM, Yahdi, Institut Teknologi Bandung, Bandung, Indonesia; PRICE, Gilbert, University of Queensland, Redbank Plains, Australia; RIZAL, Yan, Institut Teknologi Bandung, Bandung, Indonesia; SASHI, Awan, Institut Teknologi Bandung, Bandung, Indonesia; PUSPANINGRUM, Mika, Institut Teknologi Bandung, Bandung, Indonesia; TRHASCARYO, Agus, Institut Teknologi Bandung, Bandung, Indonesia; HIGGINS, Penny, University of Rochester, Rochester, NY, United States of America; ROBERTS, Patrick, Max Planck, Jena, Germany

Sumatra is the world’s sixth largest island, and Indonesia’s largest. It hosts 201 mammal species, of which nine are endemic to mainland Sumatra, fourteen to Mentawai islands, and 22 found nowhere else in Indonesia. Unlike other major islands in Southeast Asia, it records very few Quaternary extinctions. Here, we report the first globally extinct taxon from the island. Hexaprotodon, the Asian hippo, is represented by the anterior portion of a second lower molar as well as some canine fragments. These were recovered from Ngilau Gupin, a cave site in the Padang Highlands. A tapir molar from the same site has been dated to at least 45,000 years old by uranium series dating. Other than the hippo, the banteng, the buffalo, and the Javan rhino became extirpated from the island, probably sometime in the historical period. Examination of carbon and oxygen isotope values from fossil and modern large mammal communities show no significant differences in either isotope

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A large part of early vertebrate history is evidenced by microfossils, fish scales and teeth abundant globally. However, fully appreciation of these important evidences is often hampered by the labor and time intensive nature of extracting information from the large number of samples, complicated to prepare. Here, we develop a novel open source machine learning approach based on Python, to automate the segmentation and reconstruction of the three-dimensional virtual models of microfossils from tomographic image stack. The current dataset includes the tomographic data of microfossils from the lower section of the Xishancun Formation (Lochkovian, Lower Devonian) of Yunnan, China. Each scanned rock, one or two centimeters cubic, contains hundreds of microfossils, and is almost impossible to prepare using traditional methods. To achieve an automated digital preparation of these fossils, we firstly apply Otsu-thresholding, a global thresholding technique, on the smoothed tomography images to obtain a set of object candidates. Small-sized candidates are often mixed with noises and hard to separate in a single slice. However, unlike noises, the 3D structures of actual fossil continually exist across slices. Accordingly, we utilize the spatial-slice coherence of adjacent frames to classify and merge the objects from candidates. Also, the preprocessing that smooths the noises blurs the sharp boundaries, making it difficult to accurately segment the narrow-shaped objects. To address it, we propose a simple linear iterative clustering (SLIC) based strategy for precise adherence of boundary. Specifically, we use SLIC algorithm to generate superpixel. Then, we apply Otsu-thresholding method again on individual superpixel to preserve the details of a narrow shape. Finally, we merge the detailed boundary shape to the previous segmentation for an accurate segmentation. After that, we could use interpolation method to reconstruct the 3D virtual models of these microfossils. An accompanying web tool is provided for other users to test and improve our approach using new data, assumptions or methods. In perspective, we believe our attempt will surely fuel further collaborations between paleontology and computer vision approaches.

Grant Information:
Strategic Priority Research Program of Chinese Academy of Sciences (Grant No. XDB26000000); the National Natural Science Foundation of China (41872023)

Regular Poster Session III (Friday, October 11, 2019, 4:15 - 6:15 PM)

NEW POSTCRANIAL MATERIALS OF ACERORHINUS YUAMOENIUS, AND THE PHYLOGENY OF ACERATHERIINA

LU, Xiaokang, Henan University of Chinese Medicine, Zhengzhou, China; TAO, Deng, Institute of Vertebrate Paleontology and Palaeoanthropology, Chinese Academy of Sciences, Beijing, China

Compared to other groups within Rhinocerotidae, Aceratheriinae is less specialized in having a homelike or small horned skull. However, the taxonomy of Aceratheriinae is confused, and the group is absolutely non-monophyletic. A recent discovery of fully preserved skeleton of early Miocene Diceratherium sandongense sp. nov., from the Shanwang Basin in China, provide us an opportunity to re-evaluate the phylogeny of Aceratheriinae. This is the first discovery of Diceratherium in East Asia, and the first study to investigate the phylogenetic of Aceratheriinae and whose position relative to other rhinocerotids subfamilies. The new specimen is characterized by the large-sized body, short and horned nasal bones, moderately retracted nasal notch with a posterior edge above P2, very large-sized lower and upper incisors, higher-crowned but less specialized cheek teeth, and less massive metaphytes. Our phylogenetic data matrix includes all genera currently regarded as aceratheres sensu lato (i.e., Mesaceratherium, Protaceratherium, and Diceratherium). The character-wise, the present analysis includes some that have been used previously in addition to 105 new ones, resulting in a data matrix of 387 characters scored for 50 rhinocerotid species and one extant tapir outgroup. Codings have been revised for several characters, both in the light of recent observations and also in order to eliminate unwarranted assumptions. The analysis recovers Teleoceratini as more closely related to Aceratherini than to Rhinocerotini, the first two tribes forming a monophyletic group within Rhinocerotidae. In contrast to previous analyses and traditional taxonomy, aceratherines from North America do not form an exclusive clade, and Mesaceratherium gaineriheimeense is placed within Teleoceratini. Another salient conclusion is the placement of Turkanatherium as a stem rhinocerotid falling outside Aceratheriinae. The change of estemates of the genera and species in the above-mentioned clades, the analysis provides a useful phylogenetic relationship with other late Neogene aceratherines.

Grant Information:
The Giganto Project is funded by the Australian Research Council (ARC).

Technical Session X (Friday, October 11, 2019, 9:00 AM)

MACHINE LEARNING BASED EARLY DEVONIAN VERTEBRATE MICROFOSSILS: TOMOGRAPHY SEGMENTATION AND RECONSTRUCTION

LU, Jing, Institute of Vertebrate Palaeontology and Palaeoanthropology, Chinese Academy of Sciences, Beijing, China; MOU, Yongli, RWTH Aachen University, Aachen, Germany; GU, Lin, National Institute of Informatics, Tokyo, Japan; ZHU, Min, Institute of Vertebrate Palaeontology and Palaeoanthropology, Chinese Academy of Sciences, Beijing, China; HU, Yuzhi, Australian National University, Canberra, Australia

This suggests there have been no significant ecological shifts over the Pleistocene at the resolution of these proxies. Unlike other Quaternary extinction events on islands, the largest herbivore on the island is still extant, suggesting that anthropogenic overkill alone is unlikely to be responsible. We suggest that an interplay between decreased carrying capacity, increased hunting, and separation from Southeast Asian source populations may have adversely affected the large, but not medium or very large, herbivores on this island.

Grant Information:
Australian Research Council Future Fellowship (FT160100450)

No. XDB26000000); the National Natural Science Foundation of China (Grant No. 31970218); the Strategic Priority Research Program of Chinese Academy of Sciences (Grant Information: Regular Poster Session III (Friday, October 11, 2019, 4:15 - 6:15 PM)

"KING KONG'S DEMISE": IMPLICATIONS FOR DIET AND EXTINCTION OF GIANTOPTHECUS BLACKI FROM PLEISTOCENE CHINA BASED ON DENTAL MICROWEAR TEXTURE ANALYSIS

LUBEEEK, Julien K., Macquarie University, Sydney, Australia; GULLY, Grant, Flinders University, Adelaide, Australia; ZHANG, Yingyi, Institute of Vertebrate Paleontology and Palaeoanthropology, Beijing, China; GU, Lin, National Institute of Informatics, Tokyo, Japan; GU, Luly, Julien K., Macquarie University, Sydney, Australia; GU LULLY, Helen, Macquarie University Sydney, Australia; LAVOIE, Robert, Fossilworks.org, Canada; MORLEY, Mike W., Flinders University, Adelaide, Australia; WESTAWAY, Kira E., Macquarie University, Sydney, Australia

Gigantopithecus blacki was the largest ape that ever lived. It was a key member of the Stegodon-Ailuropoda fauna and roamed the subtropical forests of China from ~2.0 Ma –300 ka. G. blacki is the only hominid genus to go extinct in the Pleistocene. The cause is unknown and may be related to climate or ecological stress, due to habitat alteration and reduction in vegetation. Examining G. blacki's diet may offer insights in the cause of its extinction. It is therefore the main aim of this specific diet study, as well as of the overall ‘Giganto Project’ that also includes research on stable isotopes, luminescence dating and paleonutrition. Past, pioneering studies proposed different diets (of bamboo, C3 and C4 plants) for this prehistoric ‘King Kong’, based on phytoliths, stable isotopes, trace elements, and dental microwear by 2D scanning electron microscopy (SEM). More results, however, are desirable as its diet is still poorly understood. In recent years, more sophisticated dental microwear texture analysis (DMTA) has been increasingly applied. As it is a non-destructive, innovative and visual method to study vertebrate diets in 3D, based on the wear patterns on the occlusal surface of their dentition, it may offer potential solutions to our questions. We present the first application of this repeatable and quantitative technique on G. blacki (facets 3 and 9), correlated to known diets of extinct Old World (sub)tropical frugivores (incl. hominids like Pan troglodytes and Pongo pygmaeus) and folivores (incl. Gorilla beringei and other taxa like Ailuropoda melanoleuca and Tapanus indicus). Extinct key taxa of Pongo and Ailuropoda were studied as well. The scans reveal microwear patterns that enable parameters like anisotropy, area-scale fractal complexity, scale of maximum complexity, and heterogeneity of complexity, to be assessed during dental areal surface texture analysis (DASTA) and scale-sensitive fractal analysis (SSFA). Preliminary results show a dominance of striae versus pits, indicating a preferred diet for year-round available but low nutritional foods (like leaves), with scoral but high nutritional foods (like fruits) as potential fallback. The outcomes of this study are not only relevant for understanding regional megafaunal extinctions and reconstruction of past environmental conditions, but equally important for global conservation of current endangered megafauna like the giant panda in China and mountain gorilla in Africa.

Grant Information:
The Giganto Project is funded by the Australian Research Council (ARC).
Technical Session XVII (Saturday, October 12, 2019, 11:45 AM)

CHANGES IN DINOSAUR ECOSYSTEMS FROM THE HELL CREEK FORMATION LEADING UP TO THE CRETACEOUS-PALEOGENE BOUNDARY IN NORTH AMERICA

LYSON, Tyler R., Denver Museum of Nature and Science, Denver, CO, United States of America; BERCOVICI, Antoine D., Smithsonian Institution, Washington, DC, United States of America

The Cretaceous-Paleogene (K-Pg) boundary is associated with Earth’s third largest mass extinction event. Despite being one of the best-studied intervals of time, there is considerable debate regarding the drivers and tempo of the extinction. The Deccan Traps flood basalt province and the Chicxulub bolide impact have both been suggested as drivers of the K-Pg mass extinction. With these drivers in mind, we provide a detailed and temporally constrained terrestrial fossil record that documents relative abundance of dinosaur skeletons from the latest Cretaceous of North America.

We use a high-resolution differential GPS survey and GIS to create a geostatistically interpolated model for the K-Pg boundary across a ~1200 square kilometer study area in the latest Cretaceous Hell Creek Formation of North America and plot the stratigraphic position and depositional environment for 143 dinosaur skeletons. Identification of three K-Pg boundaries with primary markers of the Chicxulub impact, 38 pollen-defined K-Pg boundaries, and six 30n/29 paleomagnetic chron boundaries throughout our study area allows us to evaluate the fossils in a high-resolution chronostratigraphic framework.

The Hell Creek skeletal dataset consists of ceratopsians (65%), Edmontosaurus (23%), Thescelosaurus (5%), tyrannosaurs (4%), pachycephalosaurs (2%), and other taxa (1%). The relative abundance of skeletons is not distributed evenly through time or depositional environment. The lower third has a relatively even distribution of ceratopsians, and the relative abundance of ceratopsian dinosaurs increases to 58% and 73% in the middle third and upper third, respectively. In addition, ceratopsians are preferentially found in mudstone overbank deposits by a 2.1:1 margin and Edmontosaurus and Thescelosaurus in sandstone riverine deposits by a 16.1:1 and 8:1 margin, respectively. The preferential occurrence of taxa with lithology, combined with a general lithologic change from a sandstone-dominated base to a mudstone-dominated top suggests depositional environmental changes, likely a result of marine transgression, is a primary driver for observed changes in Hell Creek dinosaur ecosystems. The occurrence of all large, common dinosaurs result of marine transgression, is a primary driver for observed changes in Hell Creek dinosaur ecosystems.

Investigation of morphological changes that occur during ontogeny in dinosaurs is always hindered by the limited fossil material, and relatively continuous ontogenetic series is only documented within a few dinosaur species. The poor knowledge about ontogenetic variations in ornithomimosauria prevents a deep understanding of how this group of theropods evolved morphologically and taxonomically. Sinornithomimus dongi is an edentulous ornithomimid recovered from the Upper Cretaceous Wulansuhai Formation, Suhongtu, Inner Mongolia, China. To date, at least 27 individuals of Sinornithomimus dongi have been yielded and described. Previous studies of these specimens indicate an age range of 2.7 years, missing hatchlings and adult sized individuals. Therefore, the available specimens comprise the best-documented growth series of any ornithomimid species. Here we compare the cranial morphology of a juvenile specimen (IVPP V11797-11) and a subadult one (IVPP V11797-10) based on both naked-eye observation and CT scanning which reveals new information on previously poorly known anatomical regions such as the squamosal. Our comparisons indicate several ontogenetic changes in Sinornithomimus dongi, including the neurovascular foramina along the occipital margin of the premaxilla that is more prominent in the subadults than in the juveniles, a prominent narial fossa in the anteroventral corner of the naris present in the subadult but absent in the juvenile, and the fossa on the maxillary process of the jugal larger and deeper in the subadult than in the juvenile.

Colbert Prize Poster Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)

FINITE ELEMENT ANALYSIS OF OVI RATORPO R Saur Jaws: IMPLICATIONS FOR DI E TARY INFE RENCE

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Oviraptorosaurs are a group of feathered dinosaurs that lived in Asia and North America during the Cretaceous. They are characterized by having distinct anatomical features in the skull that deviate from those of other theropods, which include the possession of a relatively deep, pneumatized skull and a beak. Basal oviraptorosaurs such as Incisivosaurus and Caudipteryx have undergone partial tooth reduction and retain a few teeth in their skulls. The mandibles of advanced oviraptorosaurs – caenagnaths and oviraptorids – are completely edentulous and developed diverse morphologies. Investigating the mandibular function and diet of oviraptorosaurs by qualitative comparison is challenging because their toothless jaws lack obvious adaptations to a certain kind of diet. Here, we conduct the first comprehensive investigation into the functional morphology of oviraptorosaur jaws using computer modelling and biomechanical techniques. We use 2D and 3D finite element analysis (FEA) to model the biomechanics of oviraptorosaur jaws. Sixteen 2D FEA models were constructed based on physical photographs and published figures. 3D models of Gigantoraptor and Nemegtomaia were developed using photogrammetry. The 3D jaw models were digitally restored before being subjected to FEA. Comparison between 2D and 3D FEA models confirms 2D models are good representations of the biomechanics of the jaws. Two loading scenarios were set up to evaluate the functional performance of oviraptorosaur jaws: 1) dorsoventral bending tests and 2) muscle-driven force analyses using the reconstructed jaw muscles. In general, the jaws of oviraptorids are more resistant to dorsoventral bending and have higher bite efficiency compared to those of caenagnaths. Substantial differences in jaw biomechanics are observed among basal oviraptorosaurs – the downturned dentary of Caudipteryx is structurally more stable than that of Incisivosaurus under bending and biting scenarios. Our results reveal a diverse functional capacity among oviraptorosaur jaws, which potentially indicates a wide dietary range.

Technical Session XIII (Friday, October 11, 2019, 3:15 PM)

CAUDAL AUTOMOTY IN MESOSAURID REPTILES AND ITS IMPLICATIONS FOR ANTI-PREDATORY BEHAVIOUR AND LOCOMOTION IN THE CLADE

MACDOUGALL, Mark J., Museum für Naturkunde, Berlin, Germany; VERRIÈRE, Antoine, Museum für Naturkunde, Berlin, Germany; WINTERICH, Tanja, Universität Bonn, Bonn, Germany; LEBLANC, Aaron R., University of Alberta, Edmonton, AB, Canada; FROBISCH, Jörg, Museum für Naturkunde, Berlin, Germany

Mesosaurs are a distinctive clade of early reptiles that adopted a secondary aquatic lifestyle in the Permian period. While their status as the first reptilian group to re-invoke aquatic environments makes them unique, one of their most puzzling and controversial features is the potential for caudal autotomy. Several researchers have described fracture planes in mesosaur caudal vertebrae - unossified regions in the middle of caudal vertebral centra - that in many extant squamates allow the tail to separate and the animal to escape from a predator’s grasp. However, the reports of fracture planes in mesosaurs have never been closely investigated beyond preliminary descriptions, which has prompted skepticism. Here, using numerous exceptionally well-preserved vertebral series, computed tomography scans, and histological sections, we provide a detailed account of fracture planes in the caudal vertebrae of several specimens from the three known mesosaur species. Fracture planes run through the middle of the centrum of all vertebrae, starting from the 8th caudal and continuing posteriorly, but do not affect the neural arches. Caudal autotomy of this type is also present in other Paleozoic tetrapod clades, specifically captorhinid reptiles and ‘microsauroids’, revealing that this trait was more prevalent among early tetrapods than previously realized. Ancestral state reconstructions indicate that it is likely a plesiomorphic feature in reptiles. Furthermore, despite mesosaurs apparently having the ability to autotomize their tail, it is unclear if they actually made use of this behaviour, as they would have had few, if any, predators in the inland sea in which they lived. However, caudal autotomy would have been useful if they were spending time on land, as has recently been suggested. The identification of fracture planes in mesosaurs also challenges the idea of a principally tail-
driven propulsion in this clade, as opposed to many other aquatic sauropods, and suggests the hindlimbs may have played a larger role in locomotion than previously assumed.

Technical Session VI (Thursday, October 10, 2019, 10:30 AM)

**DIETARY NICHES OF EARLY MIOCENE FOSSIL HOMINOIDS FROM UGANDA**

MACLATCHY, Laura M., University of Michigan, Ann Arbor, MI, United States of America; KINGSTON, John M., University of Michigan, Ann Arbor, MI, United States of America; MALONE, Marine M., University of Michigan, Ann Arbor, MI, United States of America.

The earliest fossil hominoids are found in East Africa at sites older than 20 million years, and are thought to have evolved in forested habitats. To characterize the dietary niches of fossil hominoids, we analyzed the stable carbon and oxygen isotopic signatures of five Miocene fossil catarrhine teeth from Napak and Moroto, Uganda, including those identified as *Proconsul, Rangwapithecus*, and *Morotopithecus*. In addition, we analyzed the enamel of five modern hominoid genera including *Pan, Pongo, Gorilla, Hylobates, Syndactylus*; (n=85). Seven individuals from this extant sample were chimpanzees from a single population (Nkogo, Kibale, Uganda) with known diet. Based on the tissue-specific isotope values of these chimpanzees, the published isotopic contents of their food items, and the percent of time spent feeding on each food item, we derived a δ13C enamel value for the Ngogo chimpanzees of -12.5‰. We used this value, rather than the commonly used 1%–offset between mammalian and human physiology, to calculate dietary input for the fossil specimens and other hominoids in this sample. The modern hominoid enamel samples had δ13C enamel values between ca. -18 to -14‰, more negative than the fossil hominoids, whose atmospheric-corrected values range from ca. -9 to -12‰. The fossil hominoid values are consistent with the δ13C enamel values of associated ungulate fauna in the fossil assemblages. Using the δ13C enamel - offset for physiological fractionation in fossil hominoids, the δ13C dietary input for the fossil hominoids ranged from ca. -21 to -24‰. The data (assuming a predominantly C3 environment) thus indicate that these early hominoids were foraging on more water stressed plant parts than any extant hominoid taxon, and suggest that the earliest hominoids evolved in more open environments than previously supposed, such as in woodlands or broken forests with significant seasonality, evapotranspiration, and/or irrigation.

Grant Information:
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Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)

**THE MAMMAL ASSEMBLAGE OF CRYSTAL CAVERNS AND A COMPARATIVE ANALYSIS OF CALIFORNIA CAVE DEPOSITS**

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Caves are important geologic features that facilitate the preservation of terrestrial fossils, and thus provide valuable information about local taxa and ecology. Crystall Caverns in El Dorado County (California, U.S.A.), which was excavated in 1991, contains roughly 2,000 cataloged mammal specimens from the Pleistocene. The Pleistocene age is confirmed by the presence of the extinct shrub ox *Euceratherium*; however, many of the other taxa are extant. Over 90% of the mammalian assemblage is comprised of rodents, including *Aplodontia, Neotoma, Peromyscus, and Geomys*. Of these, more than half of the rodents in the Crystal Caverns deposit belong to the genus *Aplodontia*. The abundance of *Aplodontia* in the Crystal Cavern deposit (~53% of rodent material) is striking, especially when compared to other cave deposits. In similarly aged Northern California cave deposits, aplodontiids make up less than 10% of the rodent material. This abundance may provide us with valuable ecological information on the ecosystem of the Crystal Caverns in the Pleistocene. *Aplodontia rufa*, commonly known as the Mountain Beaver, is the only remaining species in the genus Aplodontia. Mountain Beavers comprise an early diverging, morphologically primitive genus of fossorial rodents that prefer wet and densely forested areas. The high proportion of *A. rufa* at the Crystal Caverns site suggests that during the Pleistocene, the area had increased rainfall and was more heavily forested. Combining this interpretation with the modern distribution of other mammals found in the Crystal Caverns assemblage will provide further avenues for paleoenvironmental reconstruction and will help to characterize the fauna of this unique Pleistocene deposit.

Colbert Prize Poster Session (Wednesday, October 9-12, 2019, 4:15 - 6:15 PM)

**VERTEBRATE LAG DEPOSITS FROM A K/Pg BOUNDARY SECTION NEAR MALVERN, ARKANSAS, U.S.A.: NON-CATASTROPHIC ACCUMULATIONS IN RESPONSE TO SEA LEVEL CYCLICITY**


A stratigraphic section exposing the Arkadelphia Formation and Midway Group (Maastrichtian–Paleocene) near Malvern, Arkansas, contains several vertebrate lag deposits that traverse the K/Pg mass extinction boundary. These lag deposits reside directly above erosional discontinuities, with the largest occurring at the K/Pg boundary. An abundance of disarticulated vertebrate bones and teeth deriving from modern earlys, osteodermis, pleiostauroids, and chelonians occur within these lag deposits and show evidence for multiple stages of exhumation and reburial. Comparison of these lag deposits to regional and global sea level curves indicates that they are the product of multiple exhumation and reburial events that occurred during as many as four, third order regressive-transgressive sea level cycles and accumulated over a duration of at least several million years. Preservation and taphonomic features found in these vertebrate lag deposits that traverse the K/Pg mass extinction boundary also indicate that sea level cyclicity and habitat loss in the shallow marine environment are the primary driving forces for extinction and faunal turnover. Vertebrates within the Malvern, Arkansas, lag deposits represent non-catastrophic lag accumulations and parallel evolutionary trends seen in other K/Pg stratigraphic sections that are remote from the Chicxulub, Mexico, bolide impact site. Geochemical analysis (87Sr/86Sr, 44Ca/Ca, and Dn) of these fossil assemblages across the K/Pg boundary, currently underway, will help to constrain the biostatigraphy, paleoecology, and paleoenvironmental conditions at the site.

Regular Poster Session I (Wednesday, October 9, 2019, 4:15 - 6:15 PM)

**BRAINCASE ANATOMY AND DIGITAL ENDOCAST OF CRYTOPOPHILOSAURUS ELLIOTTI (DINOSAURIA: NEOTHEROPODA).**

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*Cryptopophusaurus elliotti* from the Sinemurian lower Hanson Formation of the Central Transantarctic Mountains has variably been considered a large crocodylomorph or a basal tetanuran theropod. It is known from a boned assemblage preserving parts of at least two individuals including two braincases. The complete holotype braincase was scanned at Ford Motor Co (Livonia MI) on an industrial computed tomography system allowing for virtual preparation of the skull, and extraction of a neurocranial endocast and basicranial pneumatic space volumes.

As in many theropods, the skull lacks ethmoidal and orbitosphenoid ossifications. The large, leaf-shaped parasphenoid rostrum is grooved along both dorsal and ventral edges and constricted at the level of the deep hypophysial fossa. A single opening for the carotid arteries pierces the dorsal sellar between the openings for CN VI. The basioccipital recess is conical and divided apically by a transverse lamina. The rostral opening is blind, while the posterior one leads into paired, asymmetric pneumatic spaces that invade the base of the occipital condyle. Paired pneumatic spaces also reach the condylar neck in *Sinosauropteryx* and *Murasaurus*, but are only known invade the condyle in carnosaurous theropods. The digital endocast exhibits forebrain-midbrain and midbrain-hindbrain angles similar to other non-maniraptoran theropods like *Sinosauropteryx, Megasuchus*, and *Teyanosuchus*, but unlike the strongly angled endocasts of carnosaurous theropods. The midbrain is shorter than the medulla as is typical of both basal Tetanurae and ceratosaurans. The cerebral region is unexpanded as in *Murasaurus* and *Allosaurus*, but in contrast to *Murasaurus*. The estimated braincase Encephalization Quotient (100%) of 4.35 for the holotype specimen of *Cryptopophusaurus* is comparable to that of *Tyrannosaurus* and some paravians, yet higher than in ceratosaurians, basal...
tetanurans, and even Archaeopteryx. As in tyrannosauroids, however, much of the endocast volume was likely occupied by vascular sinuses. As one of the earliest-diverging theropods with an endocast model, Cryolophosaurus provides critical information for polarizing trends in theropod brain evolution.

Grant Information:
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Technical Session II (Wednesday, October 9, 2019, 9:30 AM)

DWARFS AMONG GIANTS: RESOLVING THE SYSTEMATICS OF THE TITANOSAURIAN SAUROPOD DINOSAURS FROM THE LATEST CRETACEOUS OF ROMANIA

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Although most famous for their gigantic size, titanosaurians also comprise some of the smallest sauropod dinosaurs, including the dwarfed taxon *Magyarosaurus*, from the latest Cretaceous of Romania. The latter genus was one of the earliest titanosaurians to be discovered, but is yet to receive any modern treatment of its anatomy, taxonomy, or phylogenetic affinities. Although the endocasts of Romanian titanosauria yielded a rich sauropod fauna, their detailed cranial record, skeletal associations are rare. The type species, *Magyarosaurus dacus*, is currently restricted to a caudal vertebra, whilst *Magyarosaurus hungaricus* is known only from a tibia and fibula. As such, *Magyarosaurus* has been largely excluded from analyses and discussion of titanosaurian evolutionary and biogeographic history. Detailed study of historical and undescribed remains enables us to build composite OTUs from a small number of overlapping, partial skeletons. We are able to refer multiple axial and appendicular remains to *Magyarosaurus dacus*. These include a tibia and fibula, which differ notably from the unusual morphology that characterizes *M. hungaricus*, otherwise known only in a small number of South American titanosaurians. Referrals of additional appendicular remains to the latter taxon enable us to further differentiate it from *M. dacus*. A poorly preserved partial skeleton with a distinct morphology demonstrates the presence of a large-bodied titanosaur, showing that this sauropod fauna was not solely composed of dwarfs. A fourth contemporaneous taxon, *Paludititan nalatzensis*, can be differentiated from *Magyarosaurus dacus*, but does not overlap with *M. hungaricus*. Unfortunately, many elements still cannot currently be referred to any taxon because of a lack of anatomical overlap. These include a well-preserved braincase. CT-scans of its internal anatomy, as well as study of its external morphology, reveal numerous differences with contemporaneous European titanosaurians. Phylogenetic analysis using TNT, based on a data matrix comprising 160 taxa scored for over 600 characters, indicates that *M. dacus*, *M. hungaricus*, and *Paludititan* are not closely related to one another. Our results support the presence of high sauropod diversity in the latest Cretaceous of Romania, and indicate a complex biogeographic assembly of this fauna. Alongside southwestern European taxa, our revision means that these Romanian sauropods can finally contribute to our understanding of the global distribution of titanosaurians, for which our biomechanical analyses indicate earlier events of geodispersal.

Grant Information:
Royal Society International Exchanges Award (IES/R1180088)

Technical Session XVIII (Saturday, October 12, 2019, 1:45 PM)

3D-RECONSTRUCTION OF MULTIPLE SPECIMENS FROM THE LOWER CRETAUCEOUS OF CHINA REVEALS CHARACTER CO-EVOLUTION TOWARD THE BAUPLAN OF BASAL THERIANS

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Therians (marsupials, placentals, and their kin), multituberculates, and monotremes survived the K-Pg impact, but multituberculates went extinct in the Eocene. The survived monotremes are represented by only five species today, in sharp contrast to therians that account for nearly the entire diversity of extant mammals (ca. 6500 species), display a great disparity in size and shape, and successfully fill the vacant ecological niches left by non-avian dinosaurs. It was assumed that therians achieved this status owing to their unique body plan, but how such a body plan ancestral to therians evolved has remained little known because of poor preservation of fossils. Here we present a new species of basal therian based on multiple nearly complete skeletal specimens preserved in three dimensions. As revealed by µCT scan, many unequivocal and detailed features from these specimens show that during the evolution of mammals, the bauplan of therians must be accomplished through transformations of many key features in a mosaic fashion, such as transformation from the reversed-triangular molar to tribosphenic molar, detachment of the auditory bones from dentary to facilitate efficient hearing, elongation and coiling of the cochlear canals accompanied by development of various structures (e.g., the secondary bony lamina, reduced lagena macula, and modified nervous and vascular systems), ossified and complicated nasal turbinals to cope with enhanced ventilation and endothermy, inflation of the olfactory bulbs, lateral expansion of cerebral hemispheres, dorsal expansion of braincase to differentiate of the midbrain, vermis and paraflocculi, and numerous changes in the postcranium to optimize the kinematics of movements. This fauna. Alongside southwestern European taxa, our results mean that the smallest sauropod dinosaurs, including the dwarfed taxon *Magyarosaurus dacus*, but does not overlap with *M. hungaricus*, from the latest Cretaceous of Romania. The latter genus was currently restricted to a caudal vertebra, whilst *Magyarosaurus hungaricus* is known only from a tibia and fibula. As such, *Magyarosaurus* has been largely excluded from analyses and discussion of titanosaurian evolutionary and biogeographic history. Detailed study of historical and undescribed remains enables us to build composite OTUs from a small number of overlapping, partial skeletons. We are able to refer multiple axial and appendicular remains to *Magyarosaurus dacus*. These include a tibia and fibula, which differ notably from the unusual morphology that characterizes *M. hungaricus*, otherwise known only in a small number of South American titanosaurians. Referrals of additional appendicular remains to the latter taxon enable us to further differentiate it from *M. dacus*. A poorly preserved partial skeleton with a distinct morphology demonstrates the presence of a large-bodied titanosaur, showing that this sauropod fauna was not solely composed of dwarfs. A fourth contemporaneous taxon, *Paludititan nalatzensis*, can be differentiated from *Magyarosaurus dacus*, but does not overlap with *M. hungaricus*. Unfortunately, many elements still cannot currently be referred to any taxon because of a lack of anatomical overlap. These include a well-preserved braincase. CT-scans of its internal anatomy, as well as study of its external morphology, reveal numerous differences with contemporaneous European titanosaurians. Phylogenetic analysis using TNT, based on a data matrix comprising 160 taxa scored for over 600 characters, indicates that *M. dacus*, *M. hungaricus*, and *Paludititan* are not closely related to one another. Our results support the presence of high sauropod diversity in the latest Cretaceous of Romania, and indicate a complex biogeographic assembly of this fauna. Alongside southwestern European taxa, our revision means that these Romanian sauropods can finally contribute to our understanding of the global distribution of titanosaurians, for which our biomechanical analyses indicate earlier events of geodispersal.

Grant Information:
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Technical Session VI (Thursday, October 10, 2019, 9:30 AM)

INTRINSIC CONSTRAINTS APPEAR TO UNDERLIE STRONG ALLOMETRIC PATTERNS IN AUSTRALIAN RODENT DIVERSE

MARCY, Ariel E., University of Queensland, St. Lucia, Australia; ROWE, Kevin C., Museums Victoria, Melbourne, Australia; SHERRATT, Emma, The University of Adelaide, Adelaide, Australia; GUILLERME, Thomas, University of Queensland, St. Lucia, Australia; PHILLIPS, Matthew J., Queensland University of Technology, Brisbane, Australia; WEISBECKER, Vera, University of Queensland, St. Lucia, Australia

Evolutionary biologists have studied allometry, or morphological variation as a function of size change, for almost a century and still debate whether intrinsic constraints or natural selection primarily drive strong allometric patterns in morphology. Theoretical research suggests it should be possible to distinguish between the constraint and selection-based hypotheses by observing patterns of static (within-species) and evolutionary (between-species) allometry. If evolutionary allometry is highly correlated with static allometry – even under intense diversifying selection such as those experienced during radiations – then this pattern supports the constraint hypothesis. As a model system, Australian rodents radiated into all major environments on the continent in under five million years, evolving diverse diets and locomotion. Despite this ecological variation, however, they have limited morphological variation, particularly in the cranial. Furthermore, Australian rodents span three orders of magnitude in size but most of their shape variation appears to be allometric. We performed 3D geometric morphometrics on 317 crania to test whether individual species and different genera had constant static and evolutionary allometric slopes, respectively. We used a time-calibrated, ultrametric tree to perform phylogenetically-corrected Procrustes ANOVAs. Among 38 species, 98.7% of pairwise comparisons of static allometric slopes were not significantly different. Among 14 genera, evolutionary allometries varied slightly, however, size and genus combined accounted for almost 67% of variation while their interaction term accounted for 6%. Recent research suggests that highly integrated animals – those with high covariation between modules within a structure – exhibit greater allometry and low allometric variation within a clad. Our results support the hypothesis that high integration in Australian rodent crania constrained their morphological evolution. Our results contrast with those from New World monkeys, which radiated under similar conditions to Australian rodents but have low cranial integration. These two mammalian clades could provide valuable systems for further untangling integration and allometry.

Grant Information:
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SCIENTIFIC METHOD ON THE MOVE: GAMES AND INTERACTIVES CONVEY THE DYNAMIC, COLLABORATIVE NATURE OF SCIENCE

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Textbooks and lab reports often make science seem as straightforward as a recipe. Even peer-reviewed articles simplify the complex, iterative, and often unexpected combination of people, events, and scientific activities that produce a new finding. Communicating this reality engages students with a more dynamic and creative view of science’s evidence-driven, problem-solving process. In 2008, the University of California Museum of Paleontology introduced their Understanding Science flowchart, which organizes a variety of scientific activities into four interactive domains: Exploration & Discovery, Community Analysis & Feedback, Benefits & Outcomes, and centrally, Testing Ideas. As opposed to a recipe, the flowchart emphasizes the non-linear and never-ending cycle of scientific inquiry. The UCMP successfully supports classrooms worldwide with the Understanding Science interactive flowchart, which encourages students to chart the paths of real scientific discoveries.

This year, we are collaborating on a new educational board game, Stunning Universe, which aims to introduce the Understanding Science model into more informal education scenarios, such as museums, science camps, and family board game nights. Since games are systems that happen to be fun, the medium is ideal to engage players with a dynamic system of scientific inquiry. In Stunning Universe, players work together to investigate uncharted parallel universes teeming with aliens! Short “Science-ing Missions” gamify an activity from one of the four domains of scientific inquiry, such as Community: Replicate a Finding. When one mission is completed, a player has some choice over which domain the next mission comes from. Their decision should take into account each player’s special ability, the group’s need to complete certain Main Objectives, and the ever-present challenge to use “Grant $$$” wisely (needed to move players’ spaceships to experiment locations and to roll the Evidence Dice). Through the game, players model cooperative scientific decision-making as well as co-author a unique story of how specific people, chance events, and new evidence shaped the winding path to stunning scientific discoveries. With these interactive resources that emphasize the nature and processes of science, our hope is that players are better able to value to essential elements of the scientific process.

Technical Session V (Wednesday, October 9, 2019, 2:45 PM)

THE SURROGATE ARM: FUNCTIONAL AND ECOLOGICAL DRIVERS OF NECK MORPHOLOGY IN EXTANT AVES

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With the forelimbs primarily adapted for flight, the avian neck allows the head to perform a variety of tasks that would be carried out by the grasping hands of their dinosaur antecedents. This has created a strong additional selection pressure on the cervical column and has resulted in the evolution of a vast array of neck morphologies in extant birds. However, no quantitative assessment of this variation has been undertaken and as such there is little understanding of how the neck evolved to become such an important component of avian biology. Here I use a holistic approach to understand functional and ecological drivers in avian neck shape and length in a diverse selection (46 species) of modern birds by combining three-dimensional geometric morphometrics with multivariate statistics and quantitative dissection. I analysed the effects of ecology on the overall morphology of the avian cervical column by comparing cervical shape trajectories of a number of ecological groups (diet and locomotor mode) using Phenotypic Trajectory Analysis. Procrustes Distance phylogenetic Generalised Least-Squares models were used to assess the impact of ecological and functional factors (neck length, body mass and head mass) on the morphology of specific cervical regions. Results show that functional, not ecological, factors (particularly body mass and neck length) correlate with much of the variation in cervical morphology in different regions of the cervical column. Specialised species with ecologies that require radically different cervical motions (such as carnivores and piscivores) are the only ecological groups to show significant variation in cervical shape. Quantitative dissection reveals that the muscles of these specialised groups have significantly different properties to other birds and these properties are linked to morphological variation in the vertebrae they attach to. Therefore, despite the appearance of abundant variability, the morphology of avian cervical column is actually highly generalised and only varies when specific cervical motions are required, such as for the tearing of flesh from prey in carnivorous taxa. The functional signal seen in both osteological and soft-tissue data instils conﬁdence in future work that will investigate the evolution of the neck of dinosaurs and the role of the cervical column as forelimbs adapt for ﬂight in early birds.

Grant Information:
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Regular Poster Session II (Thursday, October 10, 2019, 1:00 - 5:15 PM)

WHAT DO OSSIFICATION SEQUENCES TELL US ABOUT THE ORIGIN OF EXTANT AMPHIBIANS?

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The controversial origin of the extant amphibian clades has been studied using several sources of data and methods, including phylogenetic analyses of morphological data, molecular dating, stratigraphic data, and comparisons of ossification sequences. A consensus has failed to emerge, perhaps in part because the diversity of methods used hampers comparisons. We have compiled two datasets of ossification sequences of 101 extant and extinct taxa and seven cranial bones. These data allow us to assess the relative support for six currently or recently competing hypotheses about the origin(s) of the most inclusive uncontroversial extant amphibian clades: a monophyletic origin among temnospondyls, a monophyletic origin among lepospondyls, a diphyletic origin among both temnospondyls and lepospondyls, a diphyletic origin among temnospondyls alone, and two variants of a triphyletic origin, in which anurans and urodeles come from different temnospondyl taxa while caecilians come from lepospondyls and are either closer to temnospondyls (including anurans and urodeles) or to amniotes. The data were analysed through maximum likelihood, and the AICc (corrected Akaike Information Criterion) weights of the six hypotheses allow us to assess their relative support. By an unexpectedly large margin, our analyses of both datasets support a monophyletic origin among lepospondyls; a monophyletic origin among temnospondyls, the current near-consensus, is a distant second. All other hypotheses are exceedingly unlikely according to our data. Because we find a strong phylogenetic signal in the data, we are cautiously optimistic about future uses of ossification sequence data as characters in phylogenetic analyses.

Grant Information:
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Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM)

A COMPARATIVE FUNCTIONAL ANALYSIS OF FORELIMB MORPHOLOGY IN AUSTRALIAN MARSUPIALS (MARSUPIALIA)

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Digging is a common behaviour among Australian marsupials and monotremes from Australia, ranging from shallow diggings during foraging for subsurface food items to large scale burrow excavations for shelter and nesting. Functional adaptations for digging have been previously reported in both muscle anatomy and bone morphology for a range of species, however details of the co-variance between these two integrated systems has not been comprehensively studied. Without a quantitative understanding of how muscle anatomy/architecture influences bone morphology, it is difficult to draw conclusions of the significance of many morphological traits of the skeleton. In this study, we investigated the relationships between muscle architecture and bone morphology in 12 Australian marsupial species, comprising both digging and non-digging representatives from three orders (Diprotodontia, Dasyuridae, and Peramelemorphia). Principal component analysis (PCA) was used to quantify the relationships between the forelimb musculature (muscle mass and physiological cross-sectional area) and bone shape (indices that reportedly represent digging behaviour, including index of fossorial ability (IFA) and epicondyle index (EI1)). The PCA of both the muscle architecture and bone indices revealed that these quantitative measures successfully distinguish between non-digging and digging species, as well as between the three marsupial orders. The muscle architecture data and bone indices were correlated to varying degrees, indicating that the bone indices somewhat reflect observable differences in the muscle anatomy or development in response to adaptation for digging, though perhaps to a lesser.
degree than might generally be inferred in the literature. The new specimen was included in phylogenetic analysis that was conducted using maximum parsimony in PAUP on a data matrix consisting of 61 taxa scored for 136 morphological characters. This analysis generated 544,320 MPTs. The 50% majority rule tree places the Skye pterosaur as a basal monofenestran in a clade with Darwinopterus, Wukongopterus, and, for the first time, Alkaruan, which was previously identified as non-mono-fenestran. The Skye pterosaur, one of the earliest, most complete records for Monofenestrata, provides critical new insights into pterosaur evolution.

The distal end of the Skye pterosaur’s scapula is expanded and articulated with the vertebral column, a feature shared with other basal monofenestran pterosaurs. Comparisons across Pterosauria show that this type of expansion was far more common than previously realized and seemingly present in many clades, with the exception of basal-most (Late Triassic) taxa. The development of a notarium, providing additional stability and support, is confined to derived and often large and giant species and forms only part of the complex evolutionary history of the scapulo-vertebral contact.

Technical Session V (Wednesday, October 9, 2019, 3:15 PM)

A NEW LOOK AT THE LATE OLIGOCENE PLAITYDYPES PENGUINS OF ZEALANDIA

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The dense bones of penguins are predisposed to fossilise, producing an excellent record of fossil penguins in ancient shelf sediments of Zealandia - proto-New Zealand. Of note is the endemic Platydytus, one of the few described later Oligocene genera, which has been recovered mostly from the bioticlastic Otekaike Limestone of Hākataramea, Waitaki region. Other studies have identified Platydytus as one of the most crownward of the stem penguins, showing it as a precursor for the crown radiation of penguins. First named by Marples in 1952 the genus was last reviewed by Simpson in 1971. Since then new material including partially articulated skeletons, as well as
isolated bones, have been collected. Initially separated from each other by the size of the holotype of mature birds, the three named species appear to be distinct: \textit{P. novaezelandiae} (humerus length = 104mm). \textit{P. amiesi} (hl = 117mm), and \textit{P. marplei} (hl = 93mm). New material from Hakataramea, including OU22804, has shown an unnamed possible fourth species with a humerus (hl = 119mm) distinctly broader than the three named species.

Specimen OU22804 is a semi-articulated, partially-complete skeleton from the Otekaie Limestone (Waitakian, latest Oligocene), including several rarer elements; a partial mandible indicates a long spear-like bill, and a quadrate is comparable to \textit{Kairuku}: OU22116 is also a partial skeleton which has both humeri and the taxonomically diagnostic tarsometatarsus. These partial skeletons alongside the holotypes of the genus have been key in redescription of the genus. Species of \textit{Apiornodytes} (modern King and Emperor penguins), of similar size to \textit{Platypytes}, especially for interpolating incomplete vertebral columns, information valuable in revealing insight on structure, systematics and lifestyle of \textit{Platypytes}.

Preparators’ Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)

\textbf{UNEARTHING A GIANT; THE MAKING OF ZUUL}

MAY, Peter, Research Casting International, Trenton, ON, Canada; KSVSC8; EVANS, David, Royal Ontario Museum, Toronto, ON, Canada; MADILL, Amelia, Research Casting International, Trenton, ON, Canada; FAIR, Matt, Research Casting International, Trenton, ON, Canada

In June of 2014 a huge sandstone block containing a large armoured dinosaur was excavated in Hill County, Montana U.S.A. Parts of the skeleton had been exposed while quarrying for a medium sized theropod that was lying on top of this skeleton.

A skull, tail club, articulated vertebral and partial ribs were exposed in the field, small patches of skin impression, preserved armour plates and keratin indicated that there was something special to be uncovered.

In January of 2018 preparation of the Zuul body block got underway and exposed the skeleton from the hip to the base of the neck in articulation, a mold was taken, the block jacketed and a steel frame built. The block was then drilled through and cut in half with a diamond rope saw, lifted and flipped so the reverse side could be prepared, once prepped a fantastic representation of soft tissue in articulation with the skeleton was exposed.

The skeleton was then reconstructed using the information uncovered, this is the first time armature was placed in correct association and pattern on a mounted skeleton.

Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM)

\textbf{THE FIRST PECTORAL AND FORELIMB MATERIAL ASSIGNED TO THE LAGERPETID \textit{LAGERPETON CHANARENSIS}; COMPARING TO OTHER LAGERPETIDS AND OTHER AVEMETATARSALIANS}

MCCABE, Mason B., Virginia Tech, Blacksburg, VA, United States of America; NESBITT, Sterling J., Virginia Tech, Seattle, WA, United States of America

The posture of the earliest dinosaurs is thought to be bipedal whereas their pseudousuchian relatives and stem archosaurs are thought to be typically quadrupedal. Therefore, the transition from quadrupedality to bipedality lies somewhere between the origin of Avemetatarsalia (bird-line archosaurs) and Dinosauria. However, studying this transition is hampered by the lack of forelimb fossils from many of the close relatives of dinosaurs and it is not clear if the morphology of the few dinosauromorphs that have forelimb material are unique or represent the plesiomorphic condition leading to dinosaurs. New forelimb fossils of dinosaur relatives and careful assessments of their osteology is sorely needed to help address this knowledge gap. Here we present the first pectoral (left scapulocoracoid) and forelimb (right humerus) bones of the important early dinosauromorph \textit{Lagerpeton chanarensis}. The bones were prepared from a concretion that only consisted of Lagerpeton bones and from the cynodont Massetognathus. We identify the bones as belonging to Lagerpeton because the distal end of the femur possesses an inflated crista tibiofibularis – a Lagerpetid character state – and the newly recognized pectoral and forelimb bones are generally similar to those of the Lagerpetid \textit{Dromornom romeri} and Isaloper ton with tall and constricted anteroposteriorly narrow scapular blade and a humerus with a high asymmetrical proximal part of the humerus. The scapulocoracoid of Lagerpeton has a tall, but anteroposteriorly narrow scapular blade more like \textit{Dromornom romeri} than \textit{Isaloper ton}. The length of humerus and the proportions of the proximal and distal end in Lagerpeton are also more similar to that of \textit{Dromornom romeri}. Overall, the scapulocoracoids and humeri of lagerpetids are similar in proportion across taxa, but comparing the length of the forelimbs to the hindlimbs is hampered by the lack of articulated or unambiguously associated individuals of any member of the group. Currently, it is still not clear if the anatomy of the pectoral girdle and forelimb of lagerpetids, and thus posture, is unique for lagerpetids or represents the ancestral condition for dinosauromorphs.

Symposium: From Molecules to Macroevolution (Wednesday, October 9, 2019, 8:30 AM)

\textbf{NEW EVIDENCE FOR THE AFFINITY OF THE MAZON CREEK PROBLEMATIC \textit{TULLIMONSTRUM GREGARIUM}}

MCCOY, Victoria E., University of Wisconsin, Milwaukee, Milwaukee, WI, United States of America; WIEMANN, Jasmina, Yale University, New Haven, CT, United States of America; LAMSDELL, James C., West Virginia University, Morgantown, WV, United States of America; WHALEN, Christopher D., Yale University, New Haven, CT, United States of America; LIDGARD, Scott, Field Museum of Natural History, Chicago, IL, United States of America; MAYER, Paul, Field Museum of Natural History, Chicago, IL, United States of America; PIETERMANN, Holger, Yale University, New Haven, CT, United States of America; BRIGGS, Derek E., Yale University, New Haven, CT, United States of America

The affinities of \textit{Tullimonstrum gregarium}, the Tully Monster, from the Late Carboniferous Mazon Creek biota remains a matter of contention. Recent investigations placed it within vertebrates, but it has also been compared to annelids, arthropods and mollusces. These morphological analyses have yet to resolve the question of \textit{Tullimonstrum} affinity; however, chondrites, annelids, arthropods, and molluscs differ in the composition of their tissues – specifically teeth and mouthparts – suggesting that biomolecular analysis may provide relevant new information. The composition of the teeth of \textit{Tullimonstrum} would particularly be useful for distinguishing between the two best supported morphological hypotheses: chondrites have teeth composed of keratin, a protein, and molluscs have radula teeth composed of chitin. Here we investigate the composition of \textit{Tullimonstrum} teeth using Raman microspectroscopy and compare them to those in other Mazon Creek animals: chondrites and annelids (jaws) to represent proteinous tissues, arthropods, annelids (setae) and a mollusc to represent chitinous tissues. The Raman bands were not interpreted directly, but rather the whole spectra were compared using principle components analysis (PCA) to determine if the teeth of \textit{Tullimonstrum} are more similar to fossilized proteinous material, or fossilized chitinous material. PC 2 separates the definite fossilized proteinous tissues from the definite fossilized chitinous tissues into two non-overlapping groups; the \textit{Tullimonstrum} samples overlap with the proteinous group but not the chitinous group. Therefore, \textit{Tullimonstrum} teeth were similar in composition to the keratin/collagen tissues of chordates and annelids and jaws differ from the chitinous tissues in the mouthparts arthropods and molluscs and the setae of annelids. These results support a chordate identity for \textit{Tullimonstrum}.

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Technical Session IV (Wednesday, October 9, 2019, 2:00 PM)

\textbf{THE REPEATED EVOLUTION OF APICOBASAL RIDGES IN AQUATIC-FEEDING AMNIOTES}

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Over the last 250 million years, Earth’s aquatic ecosystems have been ecologically dominated by numerous lineages of predatory amniotes. Many of these groups evolved elevated ridges of enamel that run down the apical-basal axis of their teeth, referred to here as apicobasal ridges, striations or denticles. While this trait is commonly used as a taxonomic tool to identify fossil species and higher groupings, the function of the ridges and their associated ecological significance is poorly understood. Here we aim to clarify the phylogenetic distribution of apicobasal ridges among amniotes and to examine how the morphology of apicobasal ridges varies across species. We undertook a survey of museum specimens to examine the occurrence of the trait, and micro CT scanned specimens to examine their external and internal morphology. We show that these ridges have evolved independently numerous times and are already exclusively found in aquatic-feeding species. Ridge morphology varies, including tall pronged ridges, low undulating ridges and interweaving ridges. Their internal structure also varies from tooth to tooth.
crowns with locally thickened enamel to undulating enamel-dentine interface. Ridges are extremely uncommon in terrestrial feeding taxa, indicating that the function of these ridges is specific to some aspect of aquatic feeding. We find that apicobasal ridges evolve on the surface of a wide variety of tooth morphologies including those that are not normally associated with high loading regimes. Furthermore, ridge height, ridge width or the number of ridges are not correlated with characteristics associated with durophagy (thickened enamel or robust teeth). Based on these findings we propose that the ridges do not primarily serve to strengthen the tooth but instead function to either improve grip, removal efficiency and/or puncture efficiency.

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Symposium: Origin of a Sunburnt Country (Saturday, October 12, 2019, 10:30 AM)

THE PRE-EUROPEAN MAMMALS OF TASMANIA: WAS THE BASSIAN PLAIN A BRIDGE OR BARRIER?

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Tasmania, Australia’s largest continental island, was connected to mainland Australia about 75,000 years ago when global cooling caused sea-level to fall. The resulting land-bridge, known as the Bassian Plain, connected Tasmania to mainland Australia for some 60,000 years, allowing mainland mammals to colonise Tasmania and vice versa. About 14,000 years ago terrestrial Pleistocene global warming resulted in rapid sea-level rise that flooding the Bassian Plain and isolated Tasmania from mainland Australia.

Several iconic species, including the Thylacine (Thylacinus cynocephalus) and Tasmanian devil (Sarcophilus harrisii) and ‘endemic’ species, the Tasmanian pademelon (Thylotis billardierii) and Long-tailed mouse (Pseudomys higgsii), persisted or continue to flourish in Tasmania long after their mainland populations were extirpated. However, despite an abundance of suitable habitat and thousands of years of access, 16 mammals that occupy mainland Australia for some 60,000 years, allowing mainland mammals to colonise Tasmania and vice versa. About 14,000 years ago terrestrial Pleistocene global warming resulted in rapid sea-level rise that flooding the Bassian Plain and isolated Tasmania from mainland Australia.

Biodiversity and Heritage, University of Tasmania, Hobart, Australia

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A PLEISTOCENE VERTEBRATE FAUNA FROM A GROUND SLOTH SITE, GYPSUM CAVE, NEVADA, U.S.A.

The 1930’s excavation of Gypsum Cave, Nevada yielded both archaeological and fossil evidence that is relevant to understanding the prehistoric human occupation of the American Southwest. The vertebrate fossils from Gypsum Cave, a Pleistocene-age cave deposit, are an invaluable resource that provides unique paleoecological, paleoanthropological, and paleoecological insights into the Pleistocene environment of the American Southwest.

PEDAL CLAW MORPHOLOGY OF CONQUISTATORIS SANCTUS AND ITS IMPLICATIONS FOR DIET AND BEHAVIOR

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Conquistatoris sanctus is an Early Cretaceous bird from the Liaoning Province of northeastern China. Although much work has been published on this species, details of its diet and behavior remain unclear. Geometric morphometric analyses allow for the separation and comparison of specimens based on morphological variables. A geometric morphometric analysis was performed on the second pedal ungual of C. sanctus to determine how its morphology compares to that of extant birds and to elucidate details of its diet and behavior. A total of 128 specimens was examined, comprising 104 extant bird species and C. sanctus. Three fixed landmarks and 50 sliding semilandmarks were used to define shape. A principal component analysis yielded a principal component one that explained 56% of the variation among specimens and varies in the angle of claw curvature and sharpness of the claw tip. This, along with variation in centroid size, separates the extant taxa into three major behavioral groups: arboreal, terrestrial, and raptorial. The claw morphology of C. sanctus is dissimilar to extant raptorial birds, indicating that it was likely not using its claws to capture prey. C. sanctus falls within the claw morphology of extant birds displaying arboreal behavior, but also similar to extant terrestrial birds. Additionally, the robust, toothless beak of C. sanctus is suited to a granivorous or piscivorous diet. Based on this, as well as reconstructions of the Jehol ecosystem as a heavily forested lacustrine environment, it is likely that C. sanctus spent most of its time foraging for seeds and invertebrates in densely wooded areas and fishes at the edges of shallow lakes. This indicates that C. sanctus may have been more of an omnivorous and opportunistic feeder, similar to modern crows.

Technical Session X (Friday, October 11, 2019, 12:00 PM)

QUANTITATIVE ANALYSIS OF ONTOGENETIC VARIATION IN THE DENTITION OF THE GREAT WHITE SHARK (CARCHARODON CARCHARIAS) WITH IMPLICATIONS FOR THE SHARK FOSSIL RECORD

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Isolated fossil shark teeth are often used to identify fossil specimens to the level of genus or species, but these identifications can be complicated due to the degree of morphological variation expressed by the teeth. Some Recent sharks have been shown to exhibit a considerable degree of ontogenetic variation, including the Great White Shark, Carcharodon carcharias. We qualitatively and quantitatively evaluated the level of morphologic variation present in a complete set of jaws from a neonate (152 cm total length) C. carcharias. From a qualitative descriptive perspective it is clear that there is a great deal of variation expressed in the neonate jaws – for example, lateral cusp lands were inconsistently distributed across the teeth, and serrations varied considerably in size and number. We then employed geometric morphometric analyses to more rigorously compare the morphologic variation present in the neonate jaws with respect to several jaw sets from adult C. carcharias. While there was some overlap in morphology, overall the neonate jaws expressed different shapes, and a greater variation of those shapes, than what we observed in the adult teeth. We also used landmark based geometric morphometrics to compare the neonate teeth with isolated shark teeth from various other fossil and extant shark species. We found that some species, particularly the Carcharhiniform fossils, expressed a considerable degree of shape overlap with the neonate teeth. The qualitative similarity and quantitative overlap between the neonate shark teeth and certain specimens of the isolated fossil teeth from other lamniform and carcharhiniform sharks expressed a considerable degree of shape overlap with the neonate teeth. The qualitative similarity and quantitative overlap between the neonate shark teeth and certain specimens of the isolated fossil teeth from other lamniform and carcharhiniform sharks expressed a considerable degree of shape overlap with the neonate teeth. The qualitative similarity and quantitative overlap between the neonate shark teeth and certain specimens of the isolated fossil teeth from other lamniform and carcharhiniform sharks expressed a considerable degree of shape overlap with the neonate teeth. The qualitative similarity and quantitative overlap between the neonate shark teeth and certain specimens of the isolated fossil teeth from other lamniform and carcharhiniform sharks expressed a considerable degree of shape overlap with the neonate teeth.
The vertebrate integument underpins a spectrum of critical biological functions that include homeostasis, mechanical protection and coloration. Evidence of preserved integumentary structures in vertebrate fossils therefore has the potential to inform on the evolution of key anatomical innovations and associated ecological transitions. Fossilized integument typically preserves as mineralized replacements or carbonaceous residues; the latter of original integumentary colour and the evolution of feathers, but major studies have focussed on the application of these tissue components to studies of original integumentary colour and the evolution of feathers, but major questions remain regarding the biology of melanosomes and the taphonomy of melanin in keratin-based keratins. Here we present recent and current work that sheds light on these major issues, with broad implications for interpretations of the soft tissue anatomy, physiology and behaviour of fossil vertebrates.

Grant Information:
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Technical Session III (Wednesday, October 9, 2019, 2:45 PM)

THE LATE QUATERNARY ECOLOGICAL EVOLUTION OF COYOTES AS EVIDENCED FROM RANCHO LA BREA

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Coyotes are the most common canid predator of small prey in North America. However, with their flexible social structure and labile prey preference, coyotes have not been confined to a single predatory niche for their evolutionary history. Previous morphological studies have found that Pleistocene coyotes were larger and more robust than they are today. Here, we use multiple lines of evidence from the coyotes at Rancho La Brea (RLB) to build the most comprehensive picture of coyote ecological change to date. These data comprise cranial and postcranial morphology and stable isotopes tied to a precise radiocarbon chronology. We obtained radiocarbon dates and stable isotopic values on bone collagen of 121 coyote mandibles from five pit deposits at RLB: Pits 10, 3, 13, 61/67, and 91. We collected morphological measurements on these mandibles as well as on 537 postcranial elements (stylopodals, zeugopodals, and metapodals) from unassociated coyote skeletons from these deposits. Dated specimens spanned 45,000 to 750 years before present. Cranial morphological data from these specimens confirm that coyotes were larger in the Pleistocene, however mandibular shape does not change in a way that would suggest major dietary differences. Postcranial morphological results do suggest ecological differences, confirming that Pleistocene coyotes were larger overall, as well as more robust and less cursorial than modern coyotes, mirroring trends observed in wolf evolution. Pleistocene coyotes have significantly higher δ13N values than early Holocene coyotes from RLB (p<0.001), suggesting a shift in prey to animals occupying more open environments. Declining δ13N values are consistent with a shift to the consumption of smaller prey (which also have lower δ13N values relative to vegetation consumed) and/or increased consumption of plants. The coyotes we observe today – highly opportunistic carnivores known to consume small mammals, scavenge on carcasses, and eat a variety of plant resources (fruits and seeds) – are a post-Pleistocene phenomenon, and potentially a result of the extinction of numerous megafauna on the landscape.

Grant Information:
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Technical Session III (Wednesday, October 9, 2019, 3:45 PM)

ON THE FORM, MOVEMENT RANGE AND FUNCTION: CONSTRUCTING A MORPHOFUNCTIONAL SPACE FOR THE EXCAVATION MOTOR GESTURE FOR THE FORELIMB OF CARAGAUTYPOTHETERIUM MUNOZI (NOTOUNGULATA; MESOTHERIDAE)

MEDINA, Paul, Universidad Austral de Chile, Valdivia, Chile; MORENO, Karen, Universidad Austral de Chile, Valdivia, Chile

How do animals move? The answer to this question in paleontology is problematic since similar morphologies may produce a variety of functions and the opposite might be true as well, hence there is no a single response. A way to tackle this problem is to determine the maximum and minimum movement boundaries within a Morpho Functional Space (MFS). Caragautypotheterium munozii is an example of a midsize terrestrial mammal, with no modern relatives nor functional homologues. Therefore, we start exploring its motor capabilities for a forelimb digging capacity, which is allowed for other members of its Mesotheriidae family, and we compare it to a wide range of animals. Our aim was to construct an MFS considering the Effective Mechanical Advantage (EMA) of mainly wrist and elbow, as well as the Degree of Freedom joint (DFJ) in the wrist. To calculate the EMA, we obtained anatomical measurements related to the elbow extensor muscles moment arm (distance from the elbow to the tip of the olecranon) and the wrist flexor muscles (distance from the wrist to the insertion of the carpal flexors). To determine the moment arm of the ground reaction force, we obtained the moment arm (distance from both, wrist and elbow joints, to the distal end of the third phalanx of digit III). This study includes 5 different Mesotheriidae specimens, including C. munozii’s Holotype, and 38 specimens from 21 families of modern mammals, classified by their known locomotor habit. The DFJ of maximum extension and flexion were obtained from the curvature of the joint surfaces and results compared to the recorded kinematics of Vombatus ursinus while scraping a soil surface. C. munozii shows that EMA is >8% lower than a conventional forelimb model developed with the extant data. On the other hand, EMA at the wrist is about 10% higher in all Mesotheriidae versus the modern ones, and C. munozii reaches up to 30% more. The wrist extension in V. ursinus is significantly superior to the one of C. munozii (p<0.021). We conclude that C. munozii shows a markedly different motor capacity to other mammals, with a lower extensory movement range and higher mechanical advantage for the wrist flexor muscles, conditioning it to a wrist powered excavation movement.

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Technical Session VIII (Thursday, October 10, 2019, 2:15 PM)

EVOLUTION OF THE MAMMALIAN JAW JOINT AND MIDDLE EAR AT THE STAGE OF BASAL TERIANS

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In non-mammalian cynodonts, a complex of jaw bones had functioned for jaw articulation, thus mastication, as well as for sound transmission to the inner ear in hearing. During the evolution toward mammals, these jaw-joint bones reduced the size and were detached from the dentary. The latest stage of this evolutionary transition has been documented in fossils of entrodonodonts and symmetrodonts, which are taxa presumably basal to therians. This latest stage is characterized by the transitional mammalian middle ear (TMME) in which the malleus (articual and prearticual) and ectotympanic (angular) have δ18O values that have detached from the dentary but still retained significant contact with the ossified Meckel’s cartilage (OMC); the OMC was anteriorly lodged in the Meckelian groove on the rear medial surface of the dentary. Although it
considerably differs from the ancestral condition, such as that of Morganucodon, the configuration of TMME indicates that hearing and chewing in basal therians are still associated, contrasting to the condition in crown therians where these two functions and related structures are fully separated. Here we report a new Cretaceous species of basal therians that casts new light on the end stage of TMME or the beginning stage of the defining mammalian middle ear (DMME). The new species shows that the animals died at rest, probably in sleeping. High-resolution micro-CT and painstaking preparation of the specimens reveal structures critical for understanding jaw joint (chewing) and middle ear (hearing) evolution. The specimens show well-developed OMCs and their distinct residential grooves on the dentary bone. More importantly, the well-preserved auditory ossicles (the stapes, incus, malleus, surangular, and eutympanic) are nearly in situ and show many detailed morphologies unknown previously, such as the process for insertion of the stapedius muscle on the stapes and the ratio of the stapedial footplate to the tympanic membrane (as estimated from the frame well-formed by the auditory bones). In comparison with many Mesozoic forms that underwent a large amount of ossification, it is clear that the grooves are not the host for the OMC and that separation of the auditory bones from the dentary and/or the OMC must have evolved multiple times within mammals. It is also clear that the final separation of the hearing and chewing functions were affected by various factors, including body size, chewing pattern, inverteosivores diet, and selective pressure for hearing of high frequency sounds.

Grant Information:
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Technical Session VIII (Thursday, October 10, 2019, 3-15 PM)

A PHYLOGENETIC SIGNAL RETAINED IN FOSSIL SOFT TISSUES (STEM) TURTLES IN THE REPTILE TREE OF LIFE

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Fossilization transforms vertebrate soft tissues via oxidative crosslinking into chemically stable and distinct fossilization products. The most abundant structural compounds in vertebrate bone are proteins which generate characteristic S-N- and O-heterocyclic polymers during diagenesis. In living animals, proteins do not only constitute morphology, but also represent translation products of the genetic code, a prime resource for the understanding of organismic relationships. Do protein fossilization products (PFPs) record only detailed micromorphology, or also phylogeny? Here we explore potential phylogenetic signals preserved in a carefully selected set of fossil bones. Reptiles are well represented in the fossil record, and have a fairly well-known phylogeny with potentially interesting clad taxata, such as turtles. Turtles supposedly diverged from their ancestors in the Permain, and while morphology of crown and stem turtles, and sequence analyses of crown turtles are contentious, "molecular" analyses of fossil stem turtles may offer a complementary solution. We aim to use potential phylogenetic information in bone PFPs to elucidate phylogenetic affinities of stem turtles within reptiles.

Using in situ Raman Microspectroscopy (520 nm laser, 10s, 10 accumulations, 1800 gratings), we analyzed compositional heterogeneities preserved in PFPs of bones across all major reptile clades. Fossil samples were selected for their brown-blackish color and oxidative depositional environments (deduced from the chemical composition of the host rocks). Raman spectroscopic data were obtained under identical conditions, and selected for PFP-diagnostic peaks which were transformed into a variance-covariance matrix. Based on this reptile PFP matrix we ran a Principal Components Analysis to identify trends in compositional heterogeneities, in a first run without any turtle samples, and in a second run including turtle samples. Within the first ChemoSpace a distinct grouping is observed separating archosaurs from lepidosaurs, suggesting preservation of a phylogenetic signal in our reptile PFP sample. In our second ChemoSpace, stem and crown turtles fall within the archosaur cluster. Lending support to the popular idea of an archosaurian affinity of turtles, as either sister to or nested within the group. Adding more stem turtles to the data set might help to further pinpoint the position of turtles within the reptile tree of life by exploiting the phylogenetic heterogeneities preserved in their fossil soft tissues.

Technical Session XIX (Saturday, October 12, 2019, 3-30 PM)

PLANT EVOLUTION AND DIVERSIFICATION SHAPED VERTEBRATE ECOSYSTEMS DURING THE LATE CRETACEOUS AND EARLY PALEOGENE IN WESTERN NORTH AMERICA


The evolution and diversification of plants through the Late Cretaceous and into the Early Paleogene shapes the evolution and turnover in dinosauroid and placental mammal-dominated ecosystems. Fossil floras from this interval provide important insights into i) the evolutionary history of angiosperms, particularly as new food sources for vertebrates, ii) the compositional turnover of forest ecosystems, and iii) the extinction of plants at and following the Cretaceous-Paleogene (K-Pg) mass extinction.

During this critical time interval in Western North America, a nearly continuous stratigraphic record provides an excellent framework in which to study the short- and long-term changes in vegetation at a continental scale. Studies show an explosion of angiosperm species in the middle Cretaceous at low latitudes, the penecontemporaneous taxonomic demise of other major clades of plants, and then a steady northward migration of angiosperm diversity through the Late Cretaceous. By the Campanian, most fossil floras in channel or near-channel deposits are dominated by broad-leaved, woody dicot angiosperms. Some megafossils from ash falls show that while angiosperms diversified through the Late Cretaceous, they may have continued to occupy a relatively limited ecological niche. Ponds show a diverse aquatic flora and demonstrate that conifers were an important component of back swamp swamps.

Mega- and palynoflora from the K-Pg event suggest that Cretaceous forests were diverse and heterogeneous and had few taxa in common with Paleocene
forests, which were depeature and homogenous. This pattern is best-documented in the Williston and Denver Basins (North Dakota and Colorado, respectively), where ~50% of angiosperm leaf species and ~30% of palaenigmorph species disappear at the K-Pg boundary, demonstrating an instantaneous extinction with little evidence of preceding ecosystem stress. New floras from the Denver Basin that lived during the post-K-Pg extinction recovery phase indicate that pulsed climatic warming correlates with increased plant species richness and the immigration of energy-rich fruit types both of which may have supported the diversification of mammals in the Early Paleogene.

Preparers’ Session (Thursday, October 10, 2019, 1:45 PM)

PITFALLS AND SUCCESSES: THE EVOLUTION OF THE NATIONAL MUSEUM OF NATURAL HISTORY (SMITHSONIAN INSTITUTION) PALEOBIOLOGY COLLECTIONS VOLUNTEER CATALOGING PROGRAM

MILLER, Matthew T., Smithsonian Institution National Museum of Natural History, Washington, DC, United States of America; MILLHOUSE, Amanda, Smithsonian Institution National Museum of Natural History, Washington, DC, United States of America; LITTLE, Holly, Smithsonian Institution, National Museum of Natural History, Washington, DC, United States of America

As 60-70% of the workforce, the volunteers at the Smithsonian National Museum of Natural History Department of Paleobiology have an enormous impact. Historically, volunteers worked with department research staff to assist with their projects, but with a renewed focus on creating accessible, high quality digital collections records to support research we determined that integration of a larger volunteer program was necessary. Establishing this program came with many challenges and lessons learned that ultimately led to a successful volunteer effort for collections digitization.

An early brachiopod cataloging project proceeded slowly due to numerous organizational problems with the collection and highly complex data that required constant supervisorial input to resolve transcription and data quality issues. These challenges resulted in an average of 6,000 new records per year. To help curb these issues, we created a four-hour volunteer evaluation which included an hour of training, a packet of relevant information, a detailed workflow, and a cataloging exam covering a suite of specimens that ranged in difficulty entering data. Prospective volunteers that used the workflow, asked questions, could work independently, and were detail driven became catalogers.

In addition to improving volunteer vetting, we reevaluated the projects given to volunteers. The volunteers began a new project cataloging a subcollection of Wasatchian mammals. Since the data was more uniform and less complex, we could streamline data entry workflows and reduce the amount of data the volunteers collected. With the revisions, the volunteers recorded data for 17,000 mammals within the first six months of the project. Since 2016, volunteers have created over 28,000 new digital records. Though collections staff manage most of the data processing, the focused efforts and number of volunteers results in a far greater rate of data creation than our staff could achieve. Volunteers can be an asset to any cataloging project if they are trained and vetted properly, and if projects are chosen carefully. Ultimately, this increases data accessibility to the benefit of the palaeontological community.

Technical Session XV (Saturday, October 12, 2019, 12:00 PM)

ALLIGATORINE DIVERSITY DYNAMICS SUPPORT THE COMMON-CAUSE HYPOTHESIS OF MACROEVOLUTIONARY PATTERNS IN THE ROCK RECORD

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Alligatorines are used as paleothermometers. Previous analyses returned peaks over global thermal maxima in the early Paleogene and mid-Miocene. However, up-to-date taxonomies, phylogenetic hypotheses, and variation in rock exposure across time were not included, leaving potential for several sources of bias to heavily influence the results.

I compiled the most recent age estimates of all beds the oldest and youngest specimens identifiable to each currently valid alligatorine species have been found in, including a few undescribed new species, then plotted my phylogenetic hypothesis against time, resolving the single polyomry to minimize stratigraphic debt. I tabulated species richness, originations, and extinctions in four million year time bins both with and without ghost lineages and range extensions. I pulled outcrop area of fluviolacustrine and swamp rocks from North American regions and times alligatorines have been found in from Macrostrat. Data at this resolution was not available outside North America and most alligatorines have been found there. For climate, I pulled δ18O values for mean annual temperature (MAT) from a NOAA dataset. Data failed tests for normality, so I compared diversity, rocks, and climate by calculating Spearman’s rho correlation coefficients.

Alligatorine diversity tracks climate change well. Climate correlates with rock record to a lesser degree and variably—fluviolacustrine rocks decrease with increasing MAT, while swamp rocks show the opposite pattern, coinciding with the wettest part of the Cenozoic. Diversity has little correlation with rock exposure, with swamps vs. originations and presence incorporating phylogeny (but not presence without phylogenetetic data) being exceptions. There is weak to no correlation when only taxonomic ranges preserved in the fossil record are compared. There was no correlation between rocks and extinction.

In contrast to analyses based on out-of-date taxonomic data, this pattern of correlations and lack thereof show that apparent alligatorine diversity is at least not entirely a reflection of rock record bias. Rather, similar patterns are a secondary effect largely based on the co-occurrence of a warmer, wetter climate both with more swamps and higher alligatorine diversity. This supports the common-cause hypothesis—all three metrics are tied together rather than rock record bias creating apparent co-occurring changes of diversity and outcrop area. Future studies will include lithologic data outside North America.

Symposium: From Molecules to Macroevolution (Wednesday, October 9, 2019, 12:00 PM)

DIRE WOLVES WERE THE LAST OF AN ANCIENT NEW WORLD CANID LINEAGE

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The dire wolf is considered to be the most common and widespread large carnivore in Pleistocene America, yet relatively little is known about its evolution or extinction. To reconstruct the evolutionary history of dire wolves we sequenced genomes from five sub-fossil bones dating from 13,000 to over 50,000 years ago. Our results indicate that while morphologically very similar to extant gray wolf, dire wolves represent a highly divergent lineage that...
interdigitate to a greater degree than in *Eremiasaurus heterodontus*, indicating the two taxa are not synonymous. As much of the holotype of *Liodon* is missing and therefore not comparable, the referral of "*Liodon* mosasauroidea to *Eremiasaurus mosasauroidea* is proposed. This provides partial resolution for a historically problematic genus, underscoring the difficulties in interpreting poorly-preserved specimens.

Grant Information:
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**VERTEBRATE TAPHONOMY IN DISTRIBUTIVE FLUVIAL SYSTEMS**

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Approximately 8% of facies across all modern sedimentary basins are deposited as part of Distributive Fluvial Systems (DFS), a class of fan-shaped landforms including alluvial fans, fluvial fans, and megafans. There is evidence that DFS are also common in the rock record. The prevalence of DFS in the terrestrial rock record has implications for the vertebrate fossil record because as DFS deposit they prograde, producing a taxonomically rich sedimentary record and environmental changes at any one location. According to the simplest DFS model, environments will shift from poorly-drained overbank deposits with many small channels lower in section to well-drained overbank deposits with few, larger, amalgamated channels higher in section. This environmental change will affect both the distribution of organisms on the DFS and a range of taphonomic factors (e.g., transport energy, rate of burial, surficial and subsurface degradation processes). To investigate the taphonomic consequences of the DFS model a quantitative taphonomic model was written to describe changes in vertebrate preservation associated with the sedimentological and taphonomic factors present in the DFS settings. This study found that the proportion of specimens surviving to burial is projected to decrease with the magnitude of size bias in the assemblage will increase upsection. Thus limited quantitative taphonomic data are available from known or hypothesised DFS settings show some agreement with the expectations of the quantitative model. When shown to be broadly present, these results suggest that the presence of DFS in the rock record has implications for the vertebrate fossil record and should be accounted for when developing palaeoecological hypotheses.

Regular Poster Session I (Wednesday, October 9, 2019, 4:15 - 6:15 PM)

**CRYSTALLOGRAPHY OF LOURINHANOSAURUS EGGSHELLS (SAURIOPODA, THERAPODA, ALLOSAUROIDEA)**


Upper Jurassic outcrops of the Lourinhã Formation (late Kimmeridgian–Tithonian; Lusitanian Basin; Lourinhã, Portugal) are renowned by their diverse vertebrate fauna, including mammals, amphibians, squamates, testudines, crocodylomorphs and dinosaurs. Among the fossils recovered in this Formation, the record of eggs and clutches of dinosaurs and crocodylomorphs continues to be one of the most relevant. This study includes the two oldest records of theropod embryos known so far. In this study we present the first detailed report of the crystallographic architecture of the *Lourinhanosaurus* eggshell using electron backscattered diffraction (EBSD). *Lourinhanosaurus* eggshells are composed of calcite and are thin (~300 µm). The eggshells show obliqueprismatic morphology, with a mamilloary to continuous layer ratio of 1:2. The shell units are wider than in most theropod eggshells –width to height ratio of 1:3. Pore canals are wide and oblique. They
Electron backscatter analysis shows that *Lourinhoanosaurus* eggshells have a crystallographic architecture homologous to most theropod eggshells, with small crystalline domains radiating in all directions at the bases of the mammillae that transform into large columnar domains in the continuous layer. Inverse pole figure maps based on the orientation of the c-axis of the calcite crystals show a progressive reorientation of the c-axis towards the outer surface of the eggshell. At the transition point between the mammillary and continuous layers, these axes are perfectly parallel to the eggshell growth direction. Grain boundary maps show a reduced number of low angle (<5°) boundaries, with clean crystal domains separated one from the other of over 20° boundaries. The boundaries are not roughed, thus supporting the observed absence of squamous ultrastructure. The presence of the typical threedimensional architecture in an allosauroid dinosaur suggests that the eggshell growth mechanism of derived theropods was achieved early in theropod evolution.

Grant Information:
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Technical Session I (Wednesday, October 9, 2019, 11:30 AM)
THE OLDEST KNOWN PACIFIC SIRENIAN FROM THE EARLIEST Oligocene, SAIKAI, NAGASAKI PREFECTURE, WESTERN JAPAN
MORI, Hirotsugu, Gamagori Museum of Natural History, Gamagori, Aichi, Japan; MIYATA, Kazunori, Fukui Prefectural Dinosaur Museum, Katsuyama, Fukui, Japan; KATO, TakaKumi, Kurashiki University of Science and the Arts, Kurashiki, Okayama, Japan

A new fossil sirenian from Japan was collected from shallow marine strata of the Kakinoura Formation, Nishisonogi Group, Saikai, Nagasaki, western Kyushu Island. The recovered fossil remains consist of a mid-anterior vertebra, a posterior thoracic vertebra, an isolated thoracic neural spine, an anterior caudal vertebra, and a number of ribs, all from a single individual. The geologic age of the Kakinoura Formation is earliest Oligocene (Rupelian), based on calcareous nannofossils (CP 16b and 16c subzones). The anterior caudal vertebra has a hexagonal-shaped centrum and dorsoventrally thick transverse processes that project horizontally. The ribs have a dense bone histology without spongy tissue, and are pointed at their distal ends. The ribs vary in shape, with some being very thick and banana-shaped (features typical of sirenians), while others are rather narrow. The dimensions of the largest thoracic vertebral centrum (42.6 mm in width and 24.1 mm in height) and the largest rib (33.3 mm in diameter); suggest that the Saikai sirenian is one of the smallest known sirenians. It cannot be established, however, whether this individual was a juvenile or small adult.

Sirenians first evolved in the Atlantic (or western Tethys Ocean) in early Eocene time, and their sparse Paleogene record in the Pacific suggests a much later dispersal of the Pacific Ocean presumably via a seaway through Southeastern Asia. Previously, the oldest sirenian record from the western Pacific was a dugongid vertebra from late Oligocene strata in northern Kyushu. However, with identification of the Saikai sirenian, the Pacific record for this group can be extended back into the early Oligocene, suggesting a much earlier dispersal of sirenians into the Pacific. The Saikai sirenian was originally discovered in 1980, but it was only recently prepared with support from the Educational Board of Saikai City.

Grant Information:
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Technical Session XV (Saturday, October 12, 2019, 10:30 AM)
THE FIRST NON-MAMMALIAN CYONODONTS FROM AUSTRALASIA AND THE UNUSUAL NATURE OF AUSTRALIAN CRETACEOUS CONTINENTAL TETRAPOD FAUNAS
MUSSER, Anne M., Australian Museum, Sydney, Australia; LAMANNA, Matthew C., Carnegie Museum of Natural History, Pittsburgh, PA, United States of America; MARTINELLI, Agustin G., Museo Argentino Ciencias Naturales, Capital Federal, Argentina; SALGURY, Steven W., University of Queensland, Brisbane, Australia; AYHONY, Shane, Australian Museum, Sydney, Australia; JONES, Robert, Australian Museum, Sydney, Australia

Cynodont therapsids appeared by the late Permian and gave rise to mammals in the Late Triassic. Several non-mammalian cynodont clades were diverse until the Early Jurassic, but most were extinct by the mid-Cretaceous. Although these globally distributed cynodonts have an abundant fossil record in Gondwana, no representatives of this key group have yet been reported from Australia. Here we present non-mammalian cynodont remains from the early Late Cretaceous of New South Wales (NSW) and Queensland (QLD), describing or reinterpreting specimens that are here provisionally included within Haramiyida and non-mammalianiform Probainognathia, respectively. *Kollikodon ritchiei* from the Cenomanian Grintan Creek Formation of NSW was first interpreted as monotreme and subsequently as a basal australospondylid. However, distinctive characters linking *Kollikodon* to haramiyids challenge these views, including: (1) postcanines with multicusped rows; (2) orthal jaw movement (although *Kollikodon* lacked the palinal action of haramiyids); and (3) mediolateral divergence of upper postcanines, a possible haramiyid synapomorphy. Furthermore, both *Kollikodon* and the haramiyid *Haramiyavivis* have a plesiomorphic lower jaw that may have retained substantive postdentary bones. Other Australian non-mammalian cynodont fossils include a fragmentary femur and an incipiently divided molar tooth root from Cenomanian–Turonian strata of the Winton Formation in QLD. The anteroposteriorly compressed femur has an unusually long lesser trochanter like that of non-mammalianiform probainognathians (such as chiniquodontids and basal protozostrodonians) from the Late Triassic of South America and Africa. Identification of the tooth root is equivocal but it likely possesses a non-mammalian cynodont feature: incipient bifurcation of postcanine roots precedes the fully divided roots of mammals and was independently acquired in several cynodont lineages. These fossils are all substantially stratigraphically younger than those of their closest known relatives, adding to the unique and unprecedented faunal mix of archaic (e.g., temnospondyls, tarats), endemic, and relictual Gondwanan species (e.g., monoteomes) found in the Mesozoic of Australia. Australia’s late-surviving non-mammalian cynodonts fill the last void in the global distribution of these animals. The blend of typically ‘Triassic,’ ‘Jurassic,’ and ‘Cretaceous’ taxa that coexisted in the mid-Cretaceous high-latitude environs of Australasia had no parallel elsewhere.

Grant Information:
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Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)
A NEW SPECIES OF EOGRIUDEA (AVES, GRUIFORMES) FROM THE MIocene OF THE LINXIA Basin, GANSU, CHINA; EVOLUTIONARY AND CLIMATIC IMPLICATIONS.
MUSSER, Grace M., The University of Texas at Austin, Austin, TX, United States of America; LI, Zhiheng, Institute of Vertebrate Paleontology and Paleoanthropology, Beijing, China; CLARKE, Julia A., The University of Texas at Austin, Austin, TX, United States of America

Despite having one of the most robust fossil records within core-gruiform birds (rails, cranes and allies), the biogeographic history of Gruidae (cranes) and key drivers of diversification within this group remains largely unknown. The Gruidae is one of the earliest avian clades to diversify from the basal avian fossils. Here, we present description of a new species represented by a well-preserved specimen of a foot from the late Miocene (7.6-5.5Ma) Liushu Formation of Linxia Basin, Gansu, China. It is the only eogruid fossil that has been found in this Formation and is the first eogruid known from northwest China. Linxia Basin is located along the margin of the northeastern Tibetan Plateau, which allows for new insight into Miocene dispersal of the Eogruidae and potential climatological and geological connections. It is also the first specimen with an associated tarsometatarsus and nearly complete phalanges, including a claw, which provides further morphological information on this taxon. Referal of the new specimen to Eogruidae is based on extreme reduction of the metatarsal II trochlea, which is most similar to the condition present in the eogruid subclade traditionally termed Ergilornithidae.

Grant Information:
NNSF of China & Chinese Academy of Science (to ZHL), NSF GRFP (to GM, DGE-16-4486), Paleo. Soc. (Stephen J. Gould Award to GM), U.T. Austin (J.A. Wilson Fund to JC)
The notochord is a cord of soft tissue that forms in every chordate embryo and persists throughout life as the core of the vertebral column in the deeply amniotic cord of most fishes, most amphibians, and some amniotes. In other amniotes, the notochord may disappear during development or, as in mammals, may be transformed into the nucleus pulposus at the center of the intervertebral disc. In this study, we focussed on the acellular vertebrae of Choristodera, a group of semiaquatic to aquatic diapsid reptiles known from the Jurassic to the Paleogene. We examined microanatomical features of centra using X-ray CT scans and found a mineralized notochord or notochordal sheath in choristodaran genera including a basal form, Cteniognathus from the Middle Jurassic, and a derived form, Champsosaurus from the Late Cretaceous. Histological analysis revealed that a continuous filamentous matrix structure is preserved in the core of the centrum in juveniles to sub-adult Champsosaurus and adult Cteniognathus. In adult Champsosaurus, the filamentous structure was not observed in the endochondral domain, and instead, we found small masses of mineralized tissue without any visible cell structure and optical anisotropy along the longitudinal axis. A small boss or fossa at the point where the longitudinal axis meets the intervertebral surface in subadult-adult Champsosaurus indicates the persistence of a notochordal remnant at these growth stages. At the center of the centrum, we found a tiny elongated cavity that may be divided into two parts by a thin, foam-like septum in well-preserved specimens. This septum corresponds to condensed notochordal cell membranes, as observed in geckoes and tuataras, suggesting that the similar tissue in choristodaran was preferentially mineralized and preserved in the fossil vertebrae. Such a biomineralized notochord or its associated tissue has not been reported from the anniote axial skeleton and demonstrates a higher level of variation in centrum development than previously known. Furthermore, we investigated fossilized vertebrae of the enigmatic aquatic reptile Pachystropheus from the uppermost Triassic of Europe, which sometimes is considered as the oldest choristodaran. The vertebrae also show small, optically isotropic masses in the endochondral spongiosa, suggesting that the previously unknown vertebral structure was already present in the common ancestor of Pachystropheus and other choristodaran before the beginning of the Jurassic.

Grant Information:
Japan Society for the Promotion of Science KAKENHI grant 26800270
Japan Society for the Promotion of Science KAKENHI grant 18K13646

**THE ORIGIN OF DROMAEOSAUR HYPERCARNIVORY: INSIGHTS FROM MICRO-CT SCANNING OF SHANAG ASHILE**

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Microraptorine dromaeosaurids are predominantly known from two-dimensional remains that obscure many details of internal anatomy. The holotype of Shanag ashile, however, consists of an isolated but exquisite, three-dimensional maxilla and partial mandible. The specimen was so delicate that it could not be freed from matrix; however, modern high-resolution micro-CT scanning allows us to visualize its medial surface and internal anatomy. Incorporation of these observations into a phylogenetic dataset consistently recovers Shanag as a microraptorine dromaeosaurid. The CT data also yields substantial insight into microraptorine predatory ecology. Shanag possesses three deeply-rooted maxillary teeth in the middle of the toothrow, with the largest abutting the ventral margin of the maxillary fenestra. These teeth are reminiscent of those found in extant arboreal predatory squamates that heavily incorporate birds as a dietary component. We constructed a morphometric comprising 26 extinct theropods and 11 extant squamates to assess the predatory ecology of Shanag ashile and other microraptorine dromaeosaurids, which we analyzed using principal components analysis and ancestral state reconstruction in a phylogenetic framework. Microraptorines show the same pattern of morphological divergence from more basal dromaeosaurids as arboreal, bird-eating squamates do from their terrestrial relatives – they have fewer, longer, and generally straighter and more vertically inclined teeth in the maxilla and denter. This dental morphology stands in marked contrast to the many pect-like teeth found in basal paravians. The deep rooting of the largest teeth in Shanag likely represents an adaptation to resist struggling prey of a large size relative to its own. We propose that Shanag and other microraptorines were habitual bird-eaters, preying on avialans and possibly small troodontids and dromaeosaurids. Our findings suggest that dromaeosaurids began preying upon animals close to their own body size early in their evolution, and that microraptorines represent a radiation specialized for arboreal hunting of their closest relatives.

Grant Information:
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Colbert Prize Poster Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)

**ENDOCRANIAL SHAPE VARIATION IN FOSSIL AND MODERN XENARTHRAUS USING 3D GEOMETRIC MORPHOMETRICS**

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Xenarthrans (anteaters, armadillos, sloths and their fossil relatives) are one of the earliest diverging clades of placental mammals, with all members originating and diversifying in South America. The earliest xenarthran fossils, belonging to the armadillo clade, are recovered from early Eocene (~53 MA) deposits in Southeast Brazil. Sloths are first known in the fossil record from late Eocene (~36 MA) deposits and anteaters are not recovered until the early Miocene (~20 mya). Xenarthrans show the same pattern of morphologic diversification of over hundreds of species in 180 genera and 15 families; today their diversity spans 31 species, 14 genera, and 5 families. Through time this order has ranged in body mass from 100 g (the pink fairy armadillo, Chlamyphorus) to ~4,500 kg (the giant ground sloth, Megatherium), in locomotor strategy from fully sarcopterygian to aquatic, graviportal and suspensory, and in dietary preference from myrmecophagy to more general insectivory, carnivory, omnivory and folivory.

To better understand variation in xenarthran brain morphology through time and as it changes with respect to these diverse ecological variables, we use three-dimensional geometric morphometrics (GM) to quantify shape in digital endocasts derived from high-resolution X-ray computed tomography scans of representative skulls. Cranial endocasts included in the study belong to 5 species of fossil armadillo relatives, ranging in age from 23 million to 11,000 years ago, 12 species of modern armadillos, 8 species of fossil sloths, including ground and aquatic, 2 species of modern sloths, 4 species of modern anteaters, and the pangolin, Manis javanica, as an outgroup representative. In total, 30 landmarks were placed on the left side of each sampled cranial endocast. Results from a Principal Component Analysis on Procrustes shows similar patterns to those found in recent morphometric studies on mammalian digital cranial endocasts in that endocast shape variation correlates with morphologic phylogenies, with a secondary ecological signal. In particular, the location of xenarthran taxa in morphospace is influenced by both phylogeny and locomotor mode, with endocast shape separation along the 1st Principal Component axis presenting a clear divide between fossorial and terrestrial/arboral taxa. These results highlight the potential for use of GM studies on digitally derived cranial endocasts to add to our understanding of fundamental aspects of the biology of fossil xenarthrans.

Grant Information:
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The anteroconid of the first molar in the muroid rodents is a new anterior cusp seemingly appearing at the same time as the appearance of the anteroconid, the premolar that was found in the basal pre-muroid Tribosphenomys was lost in evolving murids. It has been suggested that the premolar was lost due to fusion with the developing m1, providing developing tissue to produce the anteroconid. However, studies suggest that during development, teeth inhibit one another, influencing tooth size and complexity via the inhibitory cascade mechanism. This mechanism provides an alternative hypothesis for the appearance of the anteroconid. This hypothesis further implies that there is a disparity between the potential and final shape of a tooth. Our aim was to experiment with inhibition and interactions between tooth germs in cultured tooth samples to unlock the potential of tooth shape. Using laboratory mice Mus musculus we employed a developmental approach of culturing transplanted molars of differing developmental stages together to pinpoint key timepoints of shape determination, to see how easily the anteroconid could be induced in the second molar. Importantly, we found that tooth complexity increased when inhibition was reduced, such that the second molar can express an anteroconid. As well as providing a clear mechanistic basis for the anteroconid in fossil murids, these findings have significant implications for tooth shape diversification and evolution in all vertebrates.

Grant Information:
Australian Research Council Future Fellowship FT130100968

Symposium: From Molecules to Macroevolution (Wednesday, October 9, 2019, 9:15 AM)
LIMESTONE CHICKEN WINGS: SOFT TISSUES FROM A STEM-BIRD FROM LAS HOYAS (CENTRAL SPAIN) AND THE EARLY EVOLUTION OF FLIGHT IN BIRDS
NAVALÓN, Guillermo, University of Bristol/ UAM, Cardiff, United Kingdom; MARUGÁN-LOBÓN, Jesús, Universidad Autónoma de Madrid/ Natural History Museum of Los Angeles County, Madrid, Spain; CHIAPPETTA, Luis M., Natural History Museum of Los Angeles County, Los Angeles, CA, United States of America; SANZ, José L., Universidad Autónoma de Madrid, Madrid, Spain; BUSCALIONI, Angela D., Universidad Autónoma de Madrid, Madrid, Spain

Exceptionally preserved fossil remains represent rare opportunities to access anatomical information often not available for extinct species. The limestone deposits of Las Hoyas (Cuenca, Spain) is one of the most celebrated cases of exceptional preservation of soft and hard tissues. The microbial mat-driven taphonomy of this paleowetland environment allowed pristine preservation of the fine anatomical details from the soft tissues of many vertebrae, including unique cases in the whole fossil record. Here, we show the structural and ultrastructural details of preserved connective and feather tissues in an isolated but articulated wing belonging to a stem-bird. The fossil documents one of the first occurrences in the fossil record of modern avian patagia, including propatagium, postpatagium and, remarkably, alular patagium. Within the postpatagium and in close association with the calami of flight feathers we found a series of complex striations that ultrastructurally resemble the connective system that controls flight feather movements in modern birds and guarantees aerodynamic proficiency during flight. This information reinforces the views that some lineages of stem-birds, in particular the scepsio emorphithereales, were already proficient fliers capable of developing complex flight styles. Furthermore, our analysis of the organized layers of melanine-bearing melanosomes preserved within the covert and flight feathers of this specimen suggests the wing of this bird might have been iridescent black in life, perhaps hinting diurnal habits. Our study represents a good case on how studying in detail fossil soft tissues can help unravel ecological traits in extinct species and how integrating this information in a phylogenetic context can deepen our understanding of large macroevolutionary transitions such as the origin and early evolution of flight in birds.

Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)
NEW PERSPECTIVES ON THE EVOLUTION OF THE AVIAN SKULL
NEBREDA, Sergio M., Universidad Autónoma de Madrid, Madrid, Spain; NAVALÓN, Guillermo, University of Bristol, Bristol, United Kingdom; FABBRI, Matteo, Yale University, CT, United States of America; BRIGHT, Jen A., University of South Florida, Tampa, FL, United States of America; COONEY, Christopher R., University of Sheffield, Sheffield, United Kingdom; BHULLAR, Bhart-Anjan, Yale University, New Haven, CT, United States of America; MARUGÁN-LOBÓN, Jesús, Universidad Autónoma de Madrid, Madrid, Spain; RAYFIELD, Emily J., University of Bristol, Bristol, United Kingdom

The wide array of cranial morphologies displayed by modern birds is often believed to have evolved mainly in response to tight adaptation to feeding ecology. Recent research, however, suggests that the connection between cranial morphologies and feeding ecologies in birds is not as simple and strong as often perceived. Instead, a more complex picture of the drivers affecting craniofacial diversification in birds is emerging. Here, we review some of our latest research on this topic using shape analysis, phylogenetic comparative methods and experimental development, and how our results have influenced current knowledge of the evolution of the avian skull. For instance, the concomitant evolution of shape and size (allometry) has proven to be an important factor driving skull evolution in raptors and parrots. Similarly, the coevolution of different areas of the avian skull (integration) is associated with the pattern and tempo of cranial diversification. This association allows us to understand the classic examples of adaptive radiations of passerines, suggesting that intrinsic factors, not just ecological ones, may have played a major role in shaping feeding adaptation in birds. Regardless of the specific nature of these evolutionary associations, all of them manifest over craniofacial development. On a broad macroevolutionary scale, we find that the developing brain is a major driver of avian skull evolution, constraining craniofacial development via pleiotropic associations and via physical interactions, and showing the developmental non-independence of different systems in the head. For instance, development of the beak phenotype depends on the cooperation of morphogenetic genes and their timing and area of their expression. Other alterations of development, such as heterochrony, are important drivers in the origin of the modern avian architecture and in the subsequent diversification of some lineages among the modern radiation of birds, such as strisornis. Integrating this novel information with ever-increasing amounts of ecological and morphological data, new fossil findings that fill temporal and morphological gaps in avian evolution, and new experimental data in craniofacial development, will be critical in the next years to deepen our understanding of the diversification of birds.

Symposium: From Molecules to Macroevolution (Wednesday, October 9, 2019, 11:45 AM)
DECAY CHANGES THE DISTRIBUTION AND SHAPE OF MELANOSOMES IN AQUATIC VERTEBRATES: IMPLICATIONS FOR THE INTERPRETATION OF COLOUR PATTERNS IN FOSSIL TAXA

Pigmented integument in aquatic vertebrates may serve several functions such as camouflage, intra-species communication and display. Much of the pigmentation comprises melanosomes (melanin-producing organelles) which are found throughout many organs and tissue types where they play other biological roles including as protection from microbial infection, regulating nerve impulses and chelating harmful metals. Owing to their geological stability, recognition of melanosomes has been used to make a wide variety of exciting inferences about fossil taxa. In particular, their distribution has been suggested to indicate countershading in an Ornithischian dinosaur, and colour banding in a fossil feather. Furthermore, their size and shape is utilised to determine the type of colour preserved: prolate forms corresponding to black colouration, and oblate forms responsible for more rufous colours. However, there is a preponderance of studies on terrestrial tetrapods and feathers, with little focus on basal aquatic vertebrates. Moreover, little is known about how decay can influence the shape and distribution of melanosomes throughout integument prior to fossilisation. We tested the hypothesis that the distribution and shape of fossil melanosomes from the integument of basal vertebrates is a faithful representation of in vivo pigmentation in extant analogues. We used a series of taphonomic experiments, coupled with a morphometric analysis to track the changes in melanosome shape and distribution in lamprey (cyclostomata) and several
species of patterned teleost fish during decay. Our results show that decay reduced the definition of some skin colour patterning in all species of fish whilst also creating new, distinct patterns that were not present in life. Furthermore, statistical tests on shape analysis data demonstrate that the skin integument melanosomes of lamprey retain their morphology throughout decay. This demonstrates that taphonomic processes can affect the distribution of seemingly robust pigmented structures throughout external integument. Our results further highlight the importance of understanding how the degree to which a carcass is subject to decay, coupled with the timing and onset of decay, can affect subsequent interpretations. We anticipate that further research into the taphonomic influences on pigmented integument will allow paleontologists to better answer questions surrounding the appearance, ecology and evolution of extinct organisms.

Technical Session XVII (Saturday, October 12, 2019, 9:45 AM)

ALVAREZSAUROIDEA AND EXTANT TYTONID OWLS

NEENAN, James M., University of Oxford, Oxford, United Kingdom; BENSON, Roger B., University of Oxford, Oxford, United Kingdom; SIPLA, Justin S., University of Iowa, Iowa City, IA, United States of America; GEORGI, Justin A., Midwestern University, Glendale, AZ, United States of America; WALSH, Stig A., National Museums Scotland, Edinburgh, United Kingdom; BALANOFF, Amy M., Johns Hopkins University, Baltimore, MD, United States of America; NORELL, Mark A., American Museum of Natural History, New York, NY, United States of America; XIU, Ying, Institute of Vertebrate Paleontology & Paleoanthropology, Beijing, China; CHONIERE, Jonahn N., University of the Witwatersrand, Johannesburg, South Africa

Alvarezsauroids were a widespread clade of small-bodied theropods characterized, in part, by highly derived manus morphologies that are generally considered to be specializations for digging into and feeding upon termite colonies. However, it remains unknown how alvarezsauroid sensory systems were adapted to this unusual feeding ecology, particularly with regards to hearing and visual ability. With the use of slide semilandmarks, we applied geometric morphometrics to examine vestibular (i.e., inner ear) and sclerotic ring morphologies in 126 avian and 14 non-avian theropod taxa that represent a broad phylogenetic and ecological sample. We show that the alvarezsaur, Shuvuuia deserti, has a greatly elongated endosseous cochlear duct (or ECD), which contains the basilar papilla – the region of the inner ear responsible for hearing. The ECD of S. deserti is by far the longest recorded for any non-avian theropod, and curves ventromedially to sit below the brain cavity. This condition is remarkably similar to that seen in the extinct Tyto alba (barn owl), which is well-known for its highly-sensitive directional hearing that allows it to hunt with precision in complete darkness, and for its extended high-frequency hearing range. The similarity also extends to the presence of prominent bony external ear apertures in both owls and S. deserti, which funnel sound into the external auditory meatus. Principle component analysis shows that S. deserti not only clusters with owls in morphospace, but specifically with T. alba. In addition, the early branching alvarezsaur Haplocheirus solieri shares with owls a deep, highly-concave sclerotic ring, indicating similar nocturnal visual acuity between the two groups, and deep origins of derived behaviours in alvarezsaurians.

Our results demonstrate that Alvaresauria and owls, specifically Tytonidae, convergently evolved similar, highly-specialized sensory ecologies. S. deserti had sensitive directional hearing and could have located concealed prey in complete darkness, and may have also shared a similar ability to hear extended high frequencies.

Grant Information:
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Technical Session I (Wednesday, October 9, 2019, 11:15 AM)

FIRST KNOWN MYCTICETE FROM THE FAIRHAVEN MEMBER OF THE CALVERT FORMATION

NELSON, Margot D., George Mason University, Fairfax, VA, United States of America; PEREDO, Carlos M., University of Michigan, Ann Arbor, MI, United States of America; UHEN, Mark D., George Mason University, Fairfax, VA, United States of America

The early to middle Miocene Calvert Formation has greatly informed the cetacean fossil record of eastern North America. The Plum Point Member, in particular, is renowned for fossils of both odontocetes and mysticetes, as well as other marine mammals. However, the lower member of the Calvert Formation, the Fairhaven Member, is depauperate in marine mammal fossils. There is one sirenian, Metaxytherium, and no pinnipeds. The Fairhaven Member has a small assemblage of odontocetes, namely Squidodon whitmorei, Phocaenura venustus, and Schizoderphus saltus, but mysticetes are completely unknown from the Fairhaven Member. The Burdigalian-age Fairhaven Member is thought to have accumulated in a restricted basin with deep water, as opposed to the younger Plum Point Member, which is an open shelf deposit. Here we present the first known mysticete from the Fairhaven Member of the Calvert Formation; this specimen consists of the partial cranium, including the supraoccipital, parietals, squamosals, exoccipitals, basioccipital, and possibly the frontal; the incomplete right pterygoid; and distal right mandible, with the coronoid, condyloid, and angular processes well preserved. This specimen, housed at the National Park Service’s Museum Resource Center in Landover, Maryland, was found just outside the District of Columbia from Suitland Parkway. Preliminary morphological comparisons based on size, morphology of the occipitomastoid, as well as the morphology of the periotic between the Suitland Parkway mysticete and other mysticetes known from the Plum Point Member suggest affinities with Parietobalaena, a basal chaetocetid.

Regular Poster Session I (Wednesday, October 9, 2019, 4:15 - 6:15 PM)

A NEW DINOSAUR FROM THE COELOLYSISIUS QUARRY (TEND NORIAN) INDICATES THAT LOW LATITUDE DINOSAURIAN ASSEMBLAGES REMAINED SIMILAR IN CLADE COMPOSITION THROUGHOUT THE TRIASSIC PERIOD

NEBISHT, Sterling J., Virginia Tech, Blacksburg, VA, United States of America

The origin and early evolution of dinosaurs in the Late Triassic has been documented across much of Pangea and recently refined temporal control has demonstrated that dinosaur assemblages in the low and high latitudes were distinct during much of the Norian (~228-208 mya). However, the dinosaur record at the end of the Triassic Period in the low latitudes is poor, and it is unclear whether those dinosaurian assemblages reflect more cosmopolitan or biogeographically separated taxa. The Coelophysis Quarry in western North America fills this temporal gap, yet to date, the quarry has only produced remains of the small neotheropod Coelophysis and a single individual of the theropod Daenomosaurus. Here, I recognize a third dinosaur from the Coelophysis Quarry (from Coelophysis block C-3-82), represented by much of a partially articulated skull (CM 3368) only missing the premaxilla, parts of the maxilla, and parts of the dentary. The skull (estimated length ~ 25 cm) is assigned to Dinosauria based on the combination of the following character states: anterior portion of the quadratojugal inserts into the jugal, supratemporal fossa present, and a clear gap between the exoccipitals on the basioccipital. Reconstructed skull proportions demonstrate a similar faciocranial region relative to the orbit and temporal region. The jugal of this new form is dorsoconically tall and lacks an anteroposteriorly oriented ridge, features that clearly differentiate this form from the contemporaneous dinosaurs Coelophysis bauri and Daenomosaurus. The relative size of the jugal as well as the postorbital morphology and proportions of the skull are most similar to those of Tawa hallae. Similar to Tawa, Daenomosaurus, and the early diverging sauropterygian Baurioteleosaurus, the recurved teeth of CM 3368 bear pointed and bear 4-5 minute serrations per mm. A close relationship between CM 3368 and Tawa indicates that a clade of Tawa-like dinosaurs were present from the onset of Chinle Formation deposition in the early Norian until nearly the end of the Norian (~228-208 mya). However, the early-diverging clade composed of CM 3368 + Tawa indicates that early-diverging dinosaurs in the low latitudes persisted to near the end of the Triassic. This supports a separate biogeographic province for dinosaurs in low versus high latitudes and adds that this clade was established early in dinosaur evolution and was only lost after the end of the Triassic.

Education and Outreach Poster Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)

HALF A DECADE OF LARGE-SCALE SCIENCE OUTREACH: USING THE INTERNET FORUM ASKSCIENCE TO CONNECT WITH THE PUBLIC

NESTLER, Jennifer H., University of Florida, Ft. Lauderdale, FL, United States of America; DRUMMER, Jonathan H., University of Michigan, Ann Arbor, MI, United States of America; PEREDO, Carlos M., University of Michigan, Ann Arbor, MI, United States of America; UHEN, Mark D., George Mason University, Fairfax, VA, United States of America; UN, Joo-Mi, University of Wisconsin, Madison, WI, United States of America; KAY, Jodie, University of California, San Francisco, CA, United States of America; KAUKIANGA, Capo, University of Oklahoma, Norman, OK, United States of America; MILLER, Joshua H., University of Cincinnati, Cincinnati, OH, United States of America

For the past five years, members of the Society of Vertebrate Paleontology have participated in live question-and-answer events via AskScience, a forum
on the social networking site Reddit. These events, known as "Ask Me Anything" sessions (AMAs), take place during the annual meeting with prior approval from the Society. Participants representing different disciplines volunteer time to answer questions from the public, responding to hundreds of questions and comments each year. Reddit has grown in popularity since our first AMA in 2014. As of April 2018, the discussion has over 17.4 million subscribers, up from 3.8 million in 2014. The first AMA received 17,500 unique views, while the most recent AMA (2018) received 37,300 unique views from users who actively clicked through to the AMA. Additionally, over 1.2 million people landed on a page where an AMA was featured. This reflects the popularity of our post across Reddit’s entire site, and leads to additional visibility for the Society. Over the course of several hours during the meeting, our AMA participants field questions pertaining to our stated disciplines. We also receive questions about evolution, climate change, recent discoveries, and reconstructing extinct organisms’ locomotion, behavior, and color. Furthermore, we frequently receive requests for educational or career advice, or scientists’ opinions of pop cultural references to palaeontology. In selecting panelists, we aim to maximize both the disciplines represented and a diversity of backgrounds. Given the breadth of interest, we find large, collaborative teams are particularly effective at responding to the volume and variability of questions. Recent surveys have shown that most members of the public are unable to name a single living scientist. This lack of familiarity speaks to the challenges facing the scientific community when communicating with the public, conveying the importance of their science, and justifying research funding and educational programs. Active online engagement provides scientists with a platform for directly interacting with large numbers of the public in ways that require minimal effort for all participants. In addition to communicating specifics of the science, these events also humanize the discipline, making scientists more accessible to people outside of academia.

Symposium: Origin of a Sunburnt Country (Saturday, October 12, 2019, 8:30 AM)

A FLOCK OF FOSSILS: NEW FOSSIL EVIDENCE ON THE EVOLUTION OF AUSTRALIAN SONGBIRDS (PASSERIFORMES)

NGUYEN, Jacqueline M., Australian Museum, Sydney, Australia

Birds are excellent environmental indicators because they are sensitive to habitat change and their ecological requirements are well studied. The Australian fossil record of birds can help us to understand how the progressive aridification of the continent, beginning in the Miocene, shaped the diversity and distribution of the modern avifauna. In this talk I will focus on songbirds (order Passeriformes), which are a major component of bird faunas in Australia and globally, and are believed to have originated in the Australian region before spreading to the rest of the world. I will present an overview of the latest fossil evidence of songbirds from the Riversleigh World Heritage Area, northwestern Queensland, Australia. These fossils come from several sites at Riversleigh that span the late Oligocene to the early Pleistocene, offering a unique window into regional songbird diversity over the last 25 million years. To date, the Riversleigh fossils include the oldest known records for 14 extant songbird families, and two now-extinct genera and six species. This fossil evidence indicates a shift in taxa characteristic of rainforests and other densely vegetated habitats, such as lyrebirds, logrunners, and bistelebirds, to taxa associated with more open, drier environments, similar to other densely vegetated habitats, such as lyrebirds, logrunners, and bistelebirds. This fossil evidence indicates a shift in the modern avifauna of the Riversleigh region today.

Colbert Prize Poster Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)

AN EXAMINATION OF MIocene EUROPEAN CROCODYLIAN SPECIES DIVERSITY: THE PHYLOGENETIC RELATIONSHIPS OF ITALIAN AND MALTESE TOMISTOMINES


Once a much more globally widespread crocodylian clade, Tomistominae is today represented by just one longirostrine species, Tomistoma schlegelii (the false gharial), which is restricted to the fresh waters of southeast Asia. Although tomistomine fossil occurrences are recognised from the early Eocene (~55 Ma) onwards, their remains can often be relatively incomplete, making appropriate taxonomic classification within the group particularly problematic. This is especially pertinent to several taxa from the Miocene (23.03–5.33 Ma) of Europe, which were historically erected from fragmentary remains, potentially distorting our knowledge of crocodylian species diversity. Here we re-examine and describe four contemporaneous taxa from Malta and Italy: Melitissaurus champesioides, Tomistoma carlatinum, Tomistoma gaudense, and Tomistoma lyciensis. We place them for the first time into a phylogenetic analysis, comprising 68 taxa and 245 characters, several of which are revised or novel. A unique combination of features confirms Melitissaurus champesioides to be a valid taxon, and Tomistoma carlatinum is tentatively considered to be its junior synonym. Tomistoma gaudense is deemed to be a distinct species, but given its fragmentary (and possibly juvenile) nature, a new genus name is not erected. These taxa are recovered as derived tomistomines, with characters such as a thin posterior wall of the supratemporal fenestrae, and a narrow interfenestral bar, suggesting a close relationship with the approximately contemporaneous European taxa, Tomistoma lusitanica and Geriaiosuchus gregoriensis. Tomistoma lyciensis is regarded as an indeterminate tomistomine due to its especially incomplete nature. Our taxonomic and phylogenetic revision helps to elucidate past tomistomine diversity. This is an important first step in resolving tomistomine interrelationships that will also have a bearing on constraining the routes and timings of tomistomine dispersal both throughout Europe and globally.

Grant Information:
Funded by Royal Society research grant RGF/R1/180020

Regular Poster Session I (Wednesday, October 9, 2019, 4:15 - 6:15 PM)

IMPACT OF EOCENE-OLIGOCENE GLOBAL COOLING ON THE SIZE OF LAMNIFORM SHARKS.

NOGUERA, Carmen J., Natural History Museum, London, United Kingdom; BERNARD, Emma L., The Natural History Museum, London, United Kingdom; BELHÉN, Rachel, University of Leicester, Leicester, United Kingdom; TWITCHETT, Richard J., Natural History Museum, London, United Kingdom

Body size is a key trait in all animals, reflecting interactions between life history, development, physiology and ecology. It is also affected by environmental factors such as temperature. Global warming is predicted to result in reduced body size in aquatic ectotherms such as fish, with size increase expected during episodes of global cooling. This hypothesis can be tested by analysing size change in fossil organisms during past episodes of climate change, and for large marine animals that cannot be studied in vivo, the fossil record may provide the only empirical dataset to test such predictions. The Eocene-Oligocene transition marks a major episode of global cooling. Lamniform sharks, a clade which still occupies the highest trophic-level in extant marine ecosystems, lived through that transition, and this study tested whether Eocene-Oligocene cooling drove an increase in the size of lamniform sharks, using tooth size as a proxy for body size. To quantify changes in tooth morphology, twelve morphometric variables from 690 individual teeth spanning fourteen genera were measured. Overall, tooth size increased significantly across the Eocene/Oligocene (E/O) boundary in the entire assemblage, consistent with the hypothesis that global cooling leads to an increase in the size of marine animals. However, assemblage-level differences in size could simply be due to biotic turnover at the E/O boundary and changes in taxonomic composition. Three genera in our dataset (Carcharias, Arvalselachus and Otodus) span the E/O boundary in sufficient numbers for individual analysis. All three genera record larger mean tooth sizes in the Oligocene, with significant increases in mean cusp height recorded by Otodus and Carcharias, and in both mean cusp height and width recorded by Arvalselachus. This supports the size-temperature hypothesis and the prediction that cooling results in an increase in the size of lamniform sharks. Tooth size and shape are closely linked to diet and feeding ecology. Within each genus, tooth morphospace is distinctly different in each time bin, and also differs from the morphospace occupied by extant representatives, suggesting significant changes in feeding ecology through time. Techniques used in this study can be applied to other episodes of past climate change, to better understand how lamniform ecology changed through time in response to fluctuations in global temperature.
The calcified eggshell protects a developing embryo against environmental stress and thereby contributes to the parent’s reproductive success. Since modern crocodilians and birds lay hard-shelled eggs, this eggshell type has stress and thereby contributes to the parent’s reproductive success. Since also been inferred for nonavian dinosaurs. Known dinosaur eggshell is characterized by an innermost shell membrane, an overlying protein matrix, and partial cervical collars. The torso bore three principal rows of ridged plates that grew in the dermis and during ontogeny, fused to form ‘tricorns’ of osteoderms. In the cervical region large osteoderms are underlain by base-complete forelimb). The body surface was covered by a morphological variety reveals bones unique among ornithischians. The skull was also encased by keratinous scales. The interior of the skull reveals bones unique among ornithischians. The postcranial skeleton is known in totality (including clavicles and the complete forelimb). The body surface was covered by a morphological variety of osteoderms. In the cervical region large osteoderms are underlain by baseplates that grew in the dermis and during ontogeny, fused to form ‘tricorns’ and partial cervical collars. The torso bore three principal rows of ridged osteoderms and, between these, many subsidiary osteoderms. The osteoderms of the tail have a different arrangement to those seen on the rest of the body. Most analyses position Scelidosaurus as the sister-taxa to Euparkeria (=Ankylosaurus + Stegosauria). Correcting character scores and re-running systematic analyses prompts a revision of this topology.

NORMAN, David B., University of Cambridge, Cambridge, United Kingdom

Scelidosaurus harrisonii is the first known, near-complete, ornithischian dinosaur; it is also Sinemurian (193 Ma) and therefore among the earliest members of the clade. It was described (confusingly) by Richard Owen and is, paradoxically, one of the least well-understood ornithischians. Scelidosaurus has been described in detail. Contrary to a previous understanding, the skull has a complete supraorbital series, two prominent occipital horns ‘and a large exostosis (but no osteoderm) on the mandible. The skull was also encased by keratinous scales. The interior of the skull reveals bones unique among ornithischians. The postcranial skeleton is known in totality (including clavicles and the complete forelimb). The body surface was covered by a morphological variety of osteoderms. In the cervical region large osteoderms are underlain by baseplates that grew in the dermis and during ontogeny, fused to form ‘tricorns’ and partial cervical collars. The torso bore three principal rows of ridged osteoderms and, between these, many subsidiary osteoderms. The osteoderms of the tail have a different arrangement to those seen on the rest of the body. Most analyses position Scelidosaurus as the sister-taxa to Euparkeria (=Ankylosaurus + Stegosauria). Correcting character scores and re-running systematic analyses prompts a revision of this topology.

NORWOOD, Alexandra, University of Michigan, Ann Arbor, MI, United States of America

The isotopic composition of tooth enamel provides an archive of dietary and environmental conditions ranging from daily/weekly increments to months or years, as enamel grows incrementally over long periods of time. Seasonality represents an elusive but critical climatic parameter that can be captured in this archive that records subannual differences in an animal’s diet and environment. However, to date no sampling procedures have been standardized to systematically assess climatic/resource variability utilizing detailed histological sections to inform isotopic sampling strategies. Tooth histology and enamel growth patterns and rates must be linked to the location of isotopic samples so that the time of enamel mineralization is well determined relative to other samples from the tooth and within the life history of the individual. Developing a procedure for collecting time-constrained isotopic samples from the enamel of extant zebra molars with high-resolution climatic context (including seasonal patterns) provides proof of method for application to the fossil record.

This study aims to create an integrative method for interpreting intra-tooth isotopic variability in fossil equid teeth as a proxy for seasonality in the past. This approach was established by analyzing modern assemblage of zebra (Equus grevyi) from Ol Pejeta Conservancy in Kenya, where long term climate data has been collected. Consecutive molars from all Equus grevyi individuals (n = 12) included in the study were serially sampled and the carbon and oxygen isotope ratios were analyzed with respect to known climatic conditions and seasonality at Ol Pejeta Conservancy. These results have important ramifications for paleoenvironmental studies where tracking seasonal variation of equid diet is of interest by providing a new basis for linking isotopic variability within teeth to climate change. These data provide novel insights into how isotopes from paleontological fauna can be interpreted as indicators of broader environmental change, particularly changing seasonality.

Grant Information:
Rackham Graduate Student Research Grant (University of Michigan)
Symposium: From Molecules to Macroevolution (Wednesday, October 9, 2019, 11:00 AM)

INVESTIGATING PROLIFIC PROBABLE TISSUES IN STEM BIRDS USING ADVANCED MICROSCOPIC ANALYTICAL METHODS

O’CONNOR, Jingma, Institute of Vertebrate Paleontology & Paleoanthropology, Beijing, China; BAILLEUL, Alida, Institute of Vertebrate Paleontology and Paleanthropology, Beijing, China; WANG, Min, Institute of Vertebrate Paleontology & Paleanthropology, Beijing, China; LI, Zhiheng, Institute of Vertebrate Paleontology & Paleanthropology, Beijing, China; ZHOU, Zhonghe, Institute of Vertebrate Paleontology & Paleanthropology, Beijing, China

Two types of reproductive tissues have been identified in stem birds from the Early Cretaceous Jehol Biota: maturing ovarian follicles and medullary bone. Identification of both tissues has previously relied primarily on superficial observations such as anatomical location and gross morphology. For both purported tissues there exists alternative interpretations; ovarian follicles may potentially represent misidentified stomach contents and some bone pathologies superficially resemble medullary bone. This necessitates further investigation into these preserved traces to confirm (or dispute) original interpretations, better understand the exact types of tissues that are preserved, and to clarify the taphonomic processes responsible for their fossilization. Here we investigate these two reproductive tissues at the microscopic level using standard paleohistological analyses combined with a slew of more advanced analytical techniques including histochemical staining, scanning electron microscopy (SEM), energy dispersive spectroscopy (EDS), computed tomographic (CT) and laminographic (CL) scanning, and synchrotron radiation based Fourier-transform infrared (SR-FTIR) spectroscopy. Despite the diverse range of applied methods, conclusions regarding the purported ovarian follicles are evasive. However, new data does not refute the original hypothesis.

Grant Information:
National Natural Science Foundation of China (41688103)

NEW AVALAN FOSSIL FROM THE MAEVARANO FORMATION, MAHAJANAGA BASIN, NW MADAGASCAR EXPANDS CRANIAL SHAPE DISPARITY AMONG MESOZOIC BIRDS VIA AN EXPANDED MAXILLA CONTRIBUTING TO ENHANCED ROSTRALIZATION

O’CONNOR, Patrick M., Ohio Univ, Athens, OH, United States of America; TURNER, Alan H., Stony Brook University, Stony Brook, NY, United States of America; GROENKE, Joseph R., Ohio University, Athens, OH, United States of America; FELICE, Ryan N., University College London, London, United Kingdom; ROGERS, Raymond R., Macalester College, St Paul, MN, United States of America

This approach was established by analyzing modern assemblage of zebra (Equus grevyi) from Ol Pejeta Conservancy in Kenya, where long term climate data has been collected. Consecutive molars from all Equus grevyi individuals (n = 12) included in the study were serially sampled and the carbon and oxygen isotope ratios were analyzed with respect to known climatic conditions and seasonality at Ol Pejeta Conservancy. These results have important ramifications for paleoenvironmental studies where tracking seasonal variation of equid diet is of interest by providing a new basis for linking isotopic variability within teeth to climate change. These data provide novel insights into how isotopes from paleontological fauna can be interpreted as indicators of broader environmental change, particularly changing seasonality.

Grant Information:
Rackham Graduate Student Research Grant (University of Michigan)
Symposium: From Molecules to Macroevolution (Wednesday, October 9, 2019, 11:00 AM)
The feeding behaviors of cetaceans are greatly diversified—the ways they aim at and capture the prey. However, the evolutionary process is yet to be fully understood, because it remains difficult to reconstruct the feeding behaviors of extinct taxa. We focused on the cranial mobility to the trunk of cetaceans at and capture the prey without processing. Therefore, the ROM could be a powerful tool to defining each taxon space differ. For instance, a recent study of Smilodon examined here fuse their teeth to the jaws, instead retaining a permanent multiple-tooth-rowed dentition. Unlike the condition in MTR-bearing reptiles, none of the dicynodonts multiple-tooth-rowed dentition. We hypothesize that this increase in jaw integration is an adaptation to increased hypercarnivory. Use of the continuous modularity measure described here shows promise for the analysis of modularity within and among taxa. Grant Information: NSF EAR-SGP 1757236 Symposium: Origin of a Sunburnt Country (Saturday, October 12, 2019, 9:00 AM) HOW 'OLD' IS THE AUSTRALIAN ARID ZONE: A HERP'S EYE VIEW ACROSS MOLECULES AND MORPH. OLIVER, Paul M., Griffith University, Brisbane, Australia; LEE, Michael S., South Australian Museum, Adelaide, Australia; HIPPLEY, Christie, Museums Victoria, Melbourne, Australia Australia is a predominately arid continent, but palaeoclimatic data strongly indicate this was not always the case. How, when and where, has Australia’s environmental transition from relatively mesic to largely arid occurred? Coming at this question from the perspective of reptiles, based on review of molecular and fossil data, we suggest three broad patterns that may warrant further cross-disciplinary investigation: 1) many exclusively arid and semi-arid-zone radiations (including some with specialisations associated with coastal landforms) date back at least to late Miocene (and potentially earlier); 2) the arid-zone may have functioned as a source area for surrounding biomes (especially for the savannahs of northern Australia); and 3) varying definitions, oversimplification and especially a focus on biomes at opposite ends of the climatic extremes, may have clouded our understanding of environmental history in Australia. Technical Session IV (Wednesday, October 9, 2019, 2:15 PM) TOOTH MIGRATION, REPLACEMENT, AND THE EVOLUTION OF MULTIPLE TOOTH ROWS IN ENDOIODONT DICYNODONTS (THERAPSIDA: ANOMODONTIA) GIBSON, C. The evolution of multiple tooth rows (MTRs) in dicynodonts is a significant event in herbivory evolution and has long been of interest to palaeontologists. Multiple tooth rows (MTRs) evolved several times in Amniota as a way to efficiently process plant material. In reptiles, MTRs develop via growth of the jawbone, which carries functional teeth labially before their roots can be resorbed by the development of replacement teeth. However, nearly all of our understanding of MTR evolution is restricted to reptiles, despite the occurrence of this complex structure in a therapsid: the multiple-tooth-rowed dicyonodont Endothiodon. In order to assess the applicability of the “reptilian” model of MTR evolution to Endothiodon, we examined tooth replacement patterns in μ-CT scans of Endothiodon specimens with MTRs. Additionally, we scanned an Endothiodon with single tooth rows and several close relatives of Endothiodon, allowing us to track changes in tooth development throughout Endothiodon that may have contributed to the evolution of MTRs in this therapsid. Unlike the condition in MTR-bearing reptiles, none of the dicyonodonts examined here fuse their teeth to the jaws, instead retaining a permanent gomphosis (soft tissue attachment of tooth to bone). The replacement mode is...
generally lingual in most specimens, but it is sometimes antero- or posterolinguin in the endothiodonts. Most specimens exhibit a trail of alveolar bone lingual to each functional tooth, indicating that unlike MTR development in reptiles, the teeth migrated labially from their initial sites of development and were not carried by asymmetric jaw growth. An *Endothiodon* specimen with few MTRs exhibits slight erosion of labial teeth by adjacent lingual teeth, but a specimen with many MTRs shows no evidence for erosion. In specimens with MTRs, the labial teeth are smaller than the lingual ones, suggesting that they erupted early in the animal’s life and that the addition of tooth rows took place over an extended period. Based on the above data, we propose the following mechanism for the evolution of MTRs in *Endothiodon*. In all of the endothiodonts, each tooth migrates via labial erosion of tooth and bone and lingual deposition of alveolar bone, maintaining the ligamentous attachment of the tooth to the jaw in the process. In *Endothiodon* with MTRs, the functional teeth migrate fast enough to avoid erosion by replacement teeth, allowing *Endothiodon* to retain multiple tooth generations. We therefore present a new model for MTR development outside of Reptilia, highlighting the importance of a gomphosis and tooth drift to the development of a complex dentition in endothiodonts.

Grant Information:
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Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM)
**PRELIMINARY REASSESSMENT OF THE TAXONOMY AND SYSTEMATICS OF THE GENUS *BOAVUS* MARTIS, 1871 (SERPENTES, BOOIDEA)**

ONARY, Silvio, Universidade de São Paulo, Ribeirão Preto, Brazil; HSIOU, Annie S., Universidade de São Paulo, Ribeirão Preto, Brazil; PALCI, Alessandro, Filders University, Adelaide, Australia

The genus *Boavus* comprises some important fossil forms of booids that date back to the early to middle Eocene of California and Wyoming, US. Three species were first described by Marsh (1871): *B. occidentalis*, *B. brevis* and *B. agilis*. Later, Gilmore (1938) synonymized *B. agilis* with *B. occidentalis* (senior synonym), and described a new species, *B. idelmani*, from a fairly complete and articulated skeleton, which so far constitutes the most informative specimen in the genus. Unfortunately, the type specimen of *B. idelmani* is currently in a private collection, and only its cast is available for study in the collections of the American Museum of Natural History, NY. One more species of *Boavus* was later described by Brattstrom (1955), *B. affinis*, but the type specimen was not figured. Here we present a preliminary reassessment of all the *Boavus* material, including: (a) an anatomical comparison of all the type specimens; (b) an evaluation of the taxonomic validity of the four putative species based on the inter- and intraspecific (e.g., intracolumnar variation) variability observed in modern booids; and (c) a preliminary proposal for the systematic placement of this important fossil material. We find that the justification of a distinct species for *B. affinis* is contentious, because purported diagnostic features like the triangular shape of the neural canal, the oval shape of the cotyle, and the presence of paracotylar foramina, may actually be the result of intracolumnar variation and none of them represents a reliable diagnostic/autapomorphic trait. In this sense, the lack of distinct autapomorphies combined with the same stratigraphical age of *B. affinis* and the genotype *B. occidentalis*, leads us to suggest that the former should be considered a junior synonym of the latter. With regard to the systematic placement of *Boavus* within Booidea, the genus shares some anatomical features with basal booids (i.e., charniniids, calaburids and euryids), such as the absence of prynogypophyseal processes, the absence of a median lobe or the crenate condition on the zygosphen, and the absence of parasagittal ridges; however it cannot be unequivocally assigned to any of the extant families due to the following distinctive vertebral features: (1) well lateralized confluent paradiaphyses and (2) low dorsolaterally neural spine, which arises directly from the zygosphen roof. The phylogenetic position of *Boavus* within a genus-level phylogeny of extant booids will eventually be tested upon completion of the collection of osteological data from modern forms.

Grant Information:
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Regular Poster Session I (Wednesday, October 9, 2019, 4:15 - 6:15 PM)
**HIGH-PRECISION TEMPORAL, PALEOClimATIC AND PALEOVegetationary ANALYSIS OF Oligocene vertebrate BEARING SEQUENCES IN THE RUKWA RIFT BASIN, TANZANIA**

ORR, Theresa J., James Cook University, Cairns, Australia; LAWRENCE, Leigh, James Cook University, Townsville, Australia; ROBERTS, Eric M., James Cook University, Townsville, Australia; SCHMITZ, Mark D., Boise State University, Boise, ID, United States of America; O’CONNOR, Patrick M., Ohio Univ, Athens, OH, United States of America; MTELELA, Cassy, University of Dar es Salaam, Dar es Salaam, Tanzania; STEVENS, Nancy J., Ohio Univ, Athens, OH, United States of America

The Oligocene (~25.5-24.5 Ma) Songwe Member of the Ngwwe Formation represents one of the only continental vertebrate fossil records of this age in sub-equatorial Africa, making accurate palaeoclimatic and palaeoenvironmental interpretation crucial for understanding the context of these fossils. The succession has yielded a diverse fossil assemblage of trace fossils, including the earliest evidence of fungus-farming termite nests, and both invertebrate and vertebrate fossils, highlighted by examples of the earliest apes and Old World monkeys. Many of the fossils are preserved within paleosols formed on volcanic ash-laden paleo-landscapes permitting the reconstruction of the climatic and environmental history using macromorphology and geochemistry in a highly resolved temporal framework. Results of six newly dated volcanic carbonate tuffs (conducted via U-Pb CA-ID-TIMS zircon geochronology) now correlate isolated fossil localities across the field area, and demonstrate remarkably rapid sediment accumulation rates (~30cm/ka) of the Songwe Member within a period of ~1 Ma. The paleosols represent soils that formed in a dynamic floodplain landscape that oscillated between periods of aggradation by fluvialacustrine processes, and tectonic quiescence that permitted periods of exposure and pedogenesis. Vertisols formed on lacustrine deposits, characterised by homogenous brown mudstones, whereas Aridosols and Calcisols formed on fluvial deposits, defined by normally graded, red muddy sandstones. The depth-to-calci horizon function suggests a mean annual precipitation of ~270mm through the stratigraphy, however a well-developed Vertisol sequence recorded a peak of ~1000mm mid-way through the Songwe Member at ~25 Ma. Carbonate soil thicknesses calculated precipitation seasonality ranged between 67-76mm for the argillic and calic paleosols. The carbonate soil thickness method cannot be applied to Vertisols, however vertic morphologies and illuvial clay accumulations indicate pronounced wet and dry periods. This is broadly consistent with modern Vertisols, which are observed in ustic soil moisture regimes. Stable isotope derived temperatures from pedogenic carbonates indicate mean annual temperatures ranged from 29.8 to 35.8°C, across the time period. Based on these findings the paleosols of the Songwe Member suggest that late Oligocene vertebrate faunas in the Rukwa Rift Basin existed in a tectonically and volcanically active ecosystem with a dominantly warm, semi-arid climate.

Grant Information:
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Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)
**NEW DIVERSITY IN EARLY TETRAPOD HINDLIMBS**

OTOO, Benjamin K., University of Chicago, Chicago, IL, United States of America; BOLT, John R., Field Museum, Chicago, IL, United States of America; LOMBARD, Eric, University of Chicago, Chicago, IL, United States of America; TIEFJEN, Kristen, University of Chicago, Chicago, IL, United States of America; COATES, Michael I., University of Chicago, Chicago, IL, United States of America; ANGIELCZYK, Kenneth D., Field Museum, Chicago, IL, United States of America

Recent studies of early tetrapod crania have challenged previous phylogenetic hypotheses. Comparable work on postcrania has lagged behind, reflected in low character counts in phylogenetic datasets and the greater age of prevailing evolutionary scenarios. Here we present new morphological data that support a new early hindlimb disparity and propose a distal-first pattern of morphological divergence.

New data on *Whatcheeria* reveal femoral synapomorphies with *Pederpes*, adding to a list of characters diagnosing a monophyletic Whatcheerid. However, the distal hindlimb of *Whatcheeria* differs strongly from *Pederpes* and contains at least two autapomorphies- broad, flattened epipodal eminences, an isometric, circular interepipodal space and flattened phalanges that are broader than they are long. The result is morphological conservatism in the hindlimb but divergence distally. Unexpectedly, this pattern is reinforced by the hindlimb of *Eugyrinus*, the second-oldest temnospondyl. The femur
resembles those of other early temnospondyls, but the short epipodials and number. In conjunction with new hypotheses of tetrapod relationships, the diversification in early tetrapods.

THROUGH NICHE MODELING CLARIFYING CLIMATE’S ROLE IN MEGAFAUNAL EXTINCTION THROUGH NICHE MODELING

We define the climate space that was available vs. occupied by eleven megafaunal species from the LGM to the early Holocene. We include extinct (Camelops hesternus, Mammuthus columbi, Camelops hesternus, Mammuthus columbi) and extant herbivores (Antilocapra americana, Bison, Odocileus virginianus) with varied diets and ecologies. We use maximum entropy species distribution modeling to estimate the total climatically suitable area in North America throughout each time bin, and calculate the percentage of extant species, the late Pleistocene. With few exceptions, species within the same biome are similarly constrained by mean annual temperature, temperature seasonality, annual precipitation, and precipitation variability. We found that early and middle Holocene climates were suitable for the eleven species we analyzed, seven of which are extinct, and find little evidence for a direct climatic cause of the megafaunal extinction under the assumption of niche conservatism. Collectively, these models have broad relevance and implications for megafaunal extinctions in North America, potentially pointing to other drivers of megafaunal species decline.

Grant Information:

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Regular Poster Session III (Friday, October 11, 2019, 4:15 - 6:15 PM)

THREE NEW SKULLS OF THE LATE CRETACEOUS ARMORED DINOSAUR TALARURUS PICTOSPINUS/MALEEY, 1952

Talarurus pictospinus is an ankylosaurid dinosaur from the Upper Cretaceous Bayshiree Formation (Cenomanian-Santonian) of Mongolia. Since its first discovery from the Bayan Shiree type locality in the eastern Gobi Desert, various specimens have been recovered including partial postcranial skeletons of six individuals and many other fragmentary bones. However, cranial elements of Talarurus have been rare and only two partial skulls including the holotype were described in the scientific literature. Here we present three additional skulls of Talarurus, which are much better preserved than the previously described ones. The skulls feature unique characters such as an anteriorly protruding single large interparietal caputegulum, a vertically oriented elongate frontal caputegulum with a pitted surface, an elongate lacrimal caputegulum positioned above the postorbital border of the maxilla, two longitudinally arranged large frontal caputegulae surrounded by smaller rhomboid caputegulae, small but elongate supraorbital caputegula, a posterior supraorbital caputegulum that is four times larger than the anterior one, up to three transverse parallel grooves on the dorsal surface of the posterior supraorbital caputegulum, postocular caputegulae situated along the ventral to posterior rim of the orbit and that almost extend to the anterolateral margin of the squamosal horn, a longitudinal furrow tapering towards apex of the squamosal horn, and a multiple nuchal caputegulae to five times larger than other nuchal caputegulae. The phylogenetic position of Talarurus was assessed with an updated data matrix by using TNT. Talarurus was recovered as a sister taxon to Akainacephalus, which together are the sister clade to Nodosoplosauridae. Both Akainacephalus and Nodosoplosauridae are North American taxa, and the placement of Talarurus within this clade supports a faunal exchange between North America and Asia. Other North American ankylosaurids (e.g., Ankylosaurus, Euoplocephalus, Scolosaurus) formed another clade, which was recognized as a sister group to the derived Asian taxa (e.g., Saitchianus, Tarchia, Zarzapelga) in previous studies. Our study shows that there were two distinct clades of North American ankylosaurids during the Late Cretaceous.
Grant Information:
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Technical Session I (Wednesday, October 9, 2019, 9:00 AM)

EXAMINING THE EVOLUTION OF ECHOLOCATION IN ODONTOCETES (MAMMALIA; CETACEA) VIA MORPHOLOGICAL DISPARITY OF THE COCHLEA

PARK, Travis, Natural History Museum, London, United Kingdom; COOPER, Natalie, Natural History Museum, London, United Kingdom; GUILLEMER, Thomas, University of Queensland, Brisbane, Australia

Odontocetes (toothed whales) are the most successful lineage of marine mammal, highly specialised apex predators and a key component of modern ocean ecosystems. The catalyst for their evolutionary success is their ability to use echolocation - a form of biological sonar - that allows them to sense their environment using high-frequency sound, which is produced in the cerebellum and detected by the cochlea. Recent studies have indicated that the morphology of the cochlea is an excellent proxy to distinguish hearing ability in extant and extinct taxa, allowing changes in echolocation abilities to be tracked over time. Using high-dimensional 3D geometric morphometrics (371 landmarks), we quantify shape variation in toothed whale cochleae (n = 90) and use the resulting principal component scores to calculate disparity-through-time in the clade. We found that cochlear disparity is relatively low in the Oligocene, then increases throughout the duration of the Miocene, peaking around the Miocene - Pliocene boundary, before beginning to decrease again until the present. We hypothesise that the increase in disparity coincides with the diversification of delphinoids (delphinids, phocoenids and monodontids), with several modern lineages originating contemporaneously with peak cochlear disparity. Additionally, there are statistically significant differences between platanistoid and delphinoid cochlear morphologies. Taken together, these results indicate that the refinement and specialisation of echolocation abilities in delphinoids (e.g., narrow-band high frequency hearing in phocoenids) as they spread into new ecological niches, played a role in their successful replacement of platanistoids as the dominant odontocete group during the Miocene. The apparently low cochlear disparity of stem odontocetes may be influenced by small sample size.

Grant Information:
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Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM)

TAPHONOMY AND PALEOCOMMUNITY STRUCTURE OF LD94 SITE, A MIDDLE MIOCENE FOSSIL DEPOSIT IN THE RIVERSLEIGH WORLD HERITAGE AREA, NORTHWESTERN QUEENSLAND

PARKER, Antonia H., University of New South Wales, Paddington, Australia; ARCHER, Michael, University of New South Wales, Maroubra, Australia; HAND, Suzanne J., University of New South Wales, Sydney, Australia; MYERS, Troy, University of New South Wales, Bowral, Australia

Australia has a diverse and unique modern fauna, and the Riversleigh World Heritage Area provides much of our knowledge about its evolutionary history. However, few studies have systematically examined taphonomic agents and shaped fossil preservation at Riversleigh. Focusing on Riversleigh’s relatively unstudied LD94 Site, this study describes the LD94 Local Fauna (LF), confirms the presence of new species, determines LD94’s biostratigraphic placement and provides membership of recognised paleocommunities, and identifies potential taphonomic agents involved in fossilisation of the LD94 assemblage. This adds to the deep-time history of Australian fauna through enhanced understanding of the taphonomic processes operating at one of Riversleigh’s richest fossil sites, describes a new, highly diverse local fauna, possibly a new paleocommunity and two putative new species with future research potential.

Grant Information:
Australian Research Council DP170101420

Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)

NARACOORTE CAVES: INTERPRETING THE WORLD HERITAGE OF SOUTH-EASTERN SOUTH AUSTRALIA


The caves of Naracoorte in the South-East of South Australia have long been known for their extensive deposits of Quaternary vertebrate fossils. In 1858 bone material was first reported from Blanche cave by the Reverend Julian Tenison-Woods. This was followed by relatively sporadic collection of material from various caves in the region, until a major discovery was made in the Victoria Fossil Cave in 1969. Discovered by cave explorers, the Fossil Chamber yielded a vast deposit of vertebrate fossils and became the site of intensive research for several decades. In 1994 the Naracoorte Caves received UNESCO World Heritage listing as the Australian Fossil Mammal Sites (Riversleigh/Naracoorte) for their contribution in telling the story of Australia’s unique prehistoric mammal faunas.

The Fossil Chamber has yielded almost 100 vertebrate species, including extinct megafauna. Geochronology of the site indicates a middle Pleistocene age for the deposits. Since the discovery of the chamber, visitors to the park have been able to view the deposits and see paleontologists at work on the site. This has provided an outstanding opportunity to interpret the paleontological record of the site to visitors, leaving a lasting impact on the general public. This is one of the key functions of the Naracoorte Caves World Heritage Area.

The current study titled ‘The paleoecology of Fossil Chamber small vertebrates’ will report on the understood small vertebrate fossils from Victoria Fossil Cave. Identification of vertebrate fossil (>5kg) will be undertaken on previously excavated material and dating of the site completed with faunal species being assigned to depositional layers. A detailed paleoecological reconstruction will then be reported on.

The secondary output of the research is the concurrent development of interpretive and educational material for the Victoria Fossil Cave relevant to, and stemming from, the study. Effective interpretation is essential, engaging and factual, thus a review of the current interpretative offerings from Victoria Fossil Cave is undertaken and reported on with special consideration given to the smaller vertebrate fauna (<5kg). The methodology of the interpretation is discussed and visitor engagement recorded.

It is hypothesised that the development of new interpretive materials to the Victoria Fossil Cave site with result in an increase in the engagement of the general public to the Naracoorte Caves National Park.

Grant Information:
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Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM)

REVEALING THE PALEOBIOLOGY OF AUSTRALIA’S EXTINCT MEGAFANA USING SYNCHROTRON X-RAY FLUORESCENCE MICROSCOPY: A CASE STUDY OF MACROPODIFORMES

PARKER, William M., Monash University, Melbourne, Australia; ADAMS, Justin W., Monash University, Melbourne, Australia; EVANS, Alistair R., Monash University, Melbourne, Australia

Throughout the life of a mammal, growth and development are accompanied by changes in diet and environment. Important life history events are often associated with transitions in the trait element composition of mammalian teeth. In extinct species that are disparate in ecology or body size to their modern relatives, analysis of trait element composition within teeth can be a powerful method to assess life history. Such disparity is typified by the marsupial radiations of Australia where the overwhelming majority of large-bodied species went extinct in the late Quaternary. Trace element analysis provides an avenue to understand how these giant megafaunal species underwent the altricial developmental pattern unique to marsupials. As an animal’s teeth develop, incremental lines in enamel and dentine track growth at a daily resolution. These lines may be used to determine an exact age in days at which an individual was depositing a specific region of mineralised dental tissue. Through correlating incremental growth lines in marsupial enamel with trait element concentrations it is possible to determine the age at which developmental and environmental transitions occurred in extinct marsupials. Our initial data collection at the XFM beamline of the Australian Synchrotron comprised sectioned teeth from three key macropodiform species. The Tammar Wallaby (Notamacropus eugenii) is a model species for the study of extant marsupials and has a well-documented developmental timeline. The Eastern Grey Kangaroo (Macropus giganteus eugenii, ~60 kg) is a dwarfed subspecies of extinct giant Pleistocene kangaroo (Macropus giganteus titan, ~150 kg). In analysing these closely allied subspecies, direct comparisons may be made between trace elemental indicators of development and environment for living and extinct marsupials while simultaneously allowing us to detect any impact of diagenesis. Our data demonstrates that strontium is a key trait element in this type of analysis. Initial work and subsequent subspecies appear to be reflected in the high-resolution strontium distribution mapped onto sequential teeth along the tooth row. Expanding this combined analysis of trace elements and incremental growth lines will allow us to understand marsupial development on a megafan scale.
A NEW REPTILE FROM THE MIDDLE TRIASSIC OF MADAGASCAR MAY REPRESENT THE EARLIEST-DIVERGING AVEMETATARSALIAN (ARCHOSAURIA)

PAULINA CARABAJAL, Ariana, CONICET-INIBIOMA, San Carlos de Bariloche, Argentina; NESBITT, Sterling J., Virginia Tech, Blacksburg, VA, United States of America; LEMANN, Camille, Universidad de Buenos Aires, Buenos Aires, Argentina; CARBONELL, Emilio A., Virginia Tech, Blacksburg, VA, United States of America; KAMMERER, Christian F., North Carolina Museum of Natural Sciences, Raleigh, NC, United States of America; WYSS, André, University of California Santa Barbara, Santa Barbara, CA, United States of America; FLYNN, John J., American Museum of Natural History, New York, NY, United States of America; RANVOOHARIMANANA, Lovasoa, Université d’Antananarivo, Antananarivo, Madagascar

Understanding of the evolution of the earliest avemetatarsalians (bird-line) archosaurs and the morphology of the hypothetical common ancestor of Archosauria is hampered by a poor fossil record. The earliest-diverging avemetatarsalians known, such as Telosaurus, are separated from the earliest-diverging pseudosuchians (crocodilian-line) archosaurs, and the closest outgroups of Archosauria by a clear morphological gap. Here we describe a potential early-diverging avemetatarsalians from the Middle Triassic (~230 Ma) “Basal Isalo II” beds of Madagascar, which appears to bridge these gaps. This new taxon is represented by a well-preserved partial skeleton including articulated cervical vertebrae with articulated osteoderms; a scapulocoracoid; a partial femur; isolated trunk, sacral, and caudal vertebrae; and an ilium. Noteworthy features of the specimen include: anteroposteriorly elongated vertebrae with laterally expanded dorsal ends of the neural spines, and an articulated set of osteoderms dorsal to the vertebrae. The cervical osteoderms, three pairs per vertebra, arranged in a paramedian row, and bear tapering anterior processes.

Potential synapomorphies of this specimen with avemetatarsalians include: femur with an incipient anterior trochanter, 1st sacral vertebra with a dorsally expanded sacral rib, and ilium possessing a notch on the articulation surface with the ischium. This combination of features places the new taxon at the base of Avemetatarsalia, outside aphanosaurs + dinosaurs, but this position is poorly supported. More broadly, this new specimen indicates that cervical osteoderms were present in the earliest avemetatarsalians and were soon lost in the lineage. The generally plesiomorphic morphology of the new taxon also underscores the difficulty of identifying early avemetatarsalians from incomplete skeletons. Presence of an early diverging avemetatarsalian together with a lagerpetid and silesaurid in the “Basal Isalo II” beds of Madagascar documents the co-occurrence of multiple avemetatarsalians from Gondwana during the Triassic.

Grant Information:
National Geographic Society; Field Museum of Natural History; American Museum of Natural History

Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)

PALEONEUROANATOMY OF A NEW RIOJASARAUD (DINOSAURIA, SAUROPODOMORPHA) FROM THE LATE TRIASSIC OF ARGENTINA

PAULINA CARABAJAL, Ariana, CONICET-INIBIOMA, San Carlos de Bariloche, Argentina; APALDUETTI, Cecilia, CONICET-Museo de Ciencias Naturales de San Juan, San Juan, Argentina; MARTINEZ, Ricardo, CONICET-Museo de Ciencias Naturales de San Juan, San Juan, Argentina

Here, we present the first paleoneurological study based on CT scans of the skull of a new riojasaurid sauropodoporn (PVSJ 849) from the Los Colorado Formations (Late Triassic) of Argentina. The CT scan allowed the rendering of the braincase and endocranial cavities, resulting in the most complete anatomical data for a South American representative of the clade. The cranial endocast of PVSJ 849 characterizes by a low dorsoventral expansion, cerebral hemispheres poorly expanded laterally, elongated olfactory tract and bulbs, a relatively well developed flocculus of the cerebellum, and bulbous and short pituitary. The cranial endocast has a marked sigmoidal medial in lateral view, with the olfactory bulbs aligned with the forebrain, the midbrain posteroventrally inclined and the hindbrain parallel and ventral to the forebrain. The flocculus is similar in size to that in the basul form Sauropoda tupiniquim and basal Neotheropoda, but smaller than in the sauropodoporn Plateosaurus sp (a state of character that is considered a derived condition within Sauropodoporna). The inner ear has slender semicircular canals, and the relative size of anterior, posterior and lateral semicircular canals are similar to S. tupiniquim. In dorsal view, the angle formed between anterior and posterior semicircular canals is about 80 degrees. The brain, cranial nerves and inner ear of few Triassic sauropodoporn dinosaurs have been studied, and within South American taxa these include only S. tupiniquim from Brazil. The preliminary comparisons of the neuroweaponty suggest a primitive condition within Riojassauridae, represented by PVSJ 849 with a neuroanatomy that is more similar to S. tupiniquim than to the more derived (and more closely related) Plateosaurus sp.

Grant Information:
Agencia de Investigación Científica y Tecnológica PICT 2016-0481

Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)

TEMPORAL LOBE VARIATION IN EXTANT AND FOSSIL OLD WORLD MONKEYS (CERCOPITHECIDA, CATARRHINI)

PEARSON, Alannah, The Australian National University, Canberra, Australia; POLLY, P. David, Indiana University, Bloomington, IN, United States of America; BRUNER, Emiliano, Centro Nacional de Investigación sobre la Evolución Humana, Burgos, Spain

Paleoethnologists have previously described changes in the relative proportions of cerebral regions during the evolution of Old World Monkeys (Cercopithecidae). Compared to fossil cercopithecines, extant cercopithecines have an absolute increase in total brain volume with relatively larger frontal lobes, but reduced olfactory bulbs. There is no consensus whether extant cercopithecine temporal lobes show a relative increase or decrease from fossil cercopithecines. The temporal lobe of the brain occupies the middle cranial fossa of the basiocciput with close spatial proximity associated with cranial change and indirectly impacting brain form. We aimed to clarify the correspondence between the temporal lobe and fossa through regression analysis, predicting temporal lobe volume from fossa size, before determining the variation of temporal lobe size in extant and fossil cercopithecines. Our sample included two African early Oligocene cercopithecines, Parapithecus grangeri and Aegyptopithecus zeuxis and two species of extant cercopithecines, Macaca mulatta and Cercopithecus atys. Ex vivo Computed Tomography (CT) and Micro-Computed Tomography (μCT) cranial scans produced 3D digital crania before 6 digital measurements were recorded on the endocranial surface of the fossa, approximating temporal lobe location. In vivo Magnetic Resonance Imaging (MRI) of the primate brain provided direct calculation of temporal lobe volume. Phylogenetic Least-Squares (PGLS) regression tested the correlation between temporal lobe volume and fossa size. A statistically significant correlation (r < 0.80; p < 0.05) between extant anthropoid temporal lobe volume and fossa size determined fossil predictions were reasonable. The average predicted temporal lobe volumes in extant cercopithecines were larger, absolutely, than fossil cercopithecines, however, proportion of the brain occupied by the temporal lobes was relatively smaller in extant cercopithecines than Aegyptopithecus zeuxis and Parapithecus grangeri. Despite sample size limitations, we confirm the fossa provides a suitable correlate for predicting temporal lobe volume and correspondingly that fossil cercopithecines possessed relatively larger temporal lobes compared to extant species. We note, however, that relatively smaller temporal lobes in extant species does not necessarily indicate a reduction in temporal lobe size over time but could reflect other findings on relative increase in other cerebral regions.

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Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)

FRESHWATER FISH FAUNAS FROM TWO PERMIAN RIFT VALLEYS OF ZAMBIA, WITH BIOGEOGRAPHIC IMPLICATIONS FOR SOUTHERN PANGEA

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Toward the end of the Paleozoic, Earth’s landmasses formed the supercontinent Pangea. Despite the relative lack of large-scale physical dispersal barriers, patterns of endemism and regionalization existed, likely driven by climatic conditions. Given the increasingly arid and landlocked conditions of the interior of Pangea, as well as patterns of endemism in modern aquatic rift valley faunas, the study of freshwater verteb
communities can help discern biogeographic patterns across the supercontinent.

Here we report two Permian fish assemblages from the Madumabisa Mudstone Formation of Zambia consisting of actinopterygians and large-bodied sharks, each of which is found in the immediate proximity of terrestrial tetrapod fossils. The middle Permian material is from the Mid-Zambezi Basin and consists of associated peg-and-socket scales and bony fragments belonging to an actinopterygian. The upper Permian material is from the Luangwa Basin and was collected in the 1970s, but has not been reported in detail until now. It consists of several actinopterygian fossils, including semi-articulated skeletons with dermal bones, teeth, fin rays, scales, and partial body outlines, as well as several types of ornamented dorsal fin spines belonging to euselachian sharks, the largest of which is approximately 14 cm long.

These assemblages compare well with middle and late Permian freshwater ichthyofaunas from Australia (Rangal Coal Measures, Bowen Basin), Brazil (Rio do Rasto Formation, Paraná Basin), and South Africa (Beaufort Group, Karoo Basin). However, no Permian elasmobranchs have been reported from the well sampled Karoo Basin. Our finding of comparable ichthyofaunas agrees with previous analyses of Permian ecosystem structure across southern mid to high paleolatitude, which found high similarity between basins dominated by glossopterid floras and their attendant dacyrodont therapsid consumers.

Grant Information: National Science Foundation: DDIG 1501097; EAR 1337569; EAR-1337291, EAR-1336986 National Geographic Society: NGS-158R-18, 8962-11, 8571-08

Colbert Prize Poster Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)

MAMMALIAN MORPHOLOGICAL DISPARITY IN THE CONTEXT OF LANDSCAPE EVOLUTION AND TECTONISM IN THE MIOCENE OF NORTH AMERICA

PENG, Amanda W., University of Oregon, Eugene, OR, United States of America; HOPKINS, Samantha S., University of Oregon, Eugene, OR, United States of America; DAVIS, Edward B., University of California Berkeley, Eugene, OR, United States of America

The Miocene Epoch (ca. 23.03-5.33 Ma) represents a period of great climatic and tectonic change in western North America. The Great Basin during this time is characterized by ongoing volcanic and tectonic activity, punctuated periodically by events of significant magnitude (e.g., the eruption of the Columbia River flood basalts, uplift of the Colorado Plateau and Sierra Nevada Mountains, and peak volcanism in the Great Basin) which contributed to substantial topographic changes in this region. This occurred in synchrony with long-term cooling, which was interrupted by a considerable warm interval (i.e., the Miocene Climatic Optimum, ca. 17-14.7 Ma; MCO) and followed by major cooling during the Miocene Climatic Transition (MCT, beginning around 14.8 Ma). These changes resulted in a landscape typified by relative climatic and topographic complexity which, in turn, is thought to generate biotic diversity.

While tectonic and climate changes are fundamental to the Miocene biome, these changes were also the result of changing tectonic and climate processes that have been shown to have a significant influence on the Miocene biome. We analyze disparity through a suite of measures, including mean pairwise distance and the mean distance from the centroid. Our statistical comparisons across both time and tectonic regime find that the Hemingfordian and Arikareean North American Land Mammal Ages (NALMAS; approximately aligning with the Early Miocene) display the highest average pairwise distances, indicating a more morphologically disparate population. From this disparity generally decreases following the MCO and MCT in the Middle and Late Miocene. We also observe that morphological disparity varies by tectonic regime. However, similar long-term averages exist for both the active and passive regions during the entire Miocene.

The inclusion of the Winton pterosaur in a phylogenetic analysis of Pterosauria resolved it within Anhangueria, specifically as the sister taxon to Mylitta camara and Austrosaurus molnari), each on fragmentary cranial remains from the Toolubec Formation (upper Albian) of Queensland. In April 2017, a new pterosaur specimen was discovered on a property northeast of Winton, Queensland. This specimen, which comprises a partial skull with premaxillary and dentary crests, forty teeth, five cervical vertebrae, the majority of the left wing and fragments of the right wing, is the most complete pterosaur known from Australia, and the first reported from the Winton Formation (Cenomanian–lower Turonian) of the Eromanga Basin. All of the elements are three-dimensionally preserved, with their internal spaces filled by ironstone. Although the Winton pterosaur was discovered in a fragmented state in the bank of a normally dry ephemeral creek, it is likely that the skeleton was articulated prior to erosion: the upper and lower jaws were found articulated, and several wing elements key into matrix adhering to anatomically adjacent elements.

The Australian pterosaur fossil record is poor by world standards, with fewer than 20 specimens—each comprising one or two isolated bones—reported from the entire continent. Only two taxa have been named (Mylitta camara and Austrosaurus molnari), each on fragmentary cranial remains from the Toolubec Formation (upper Albian) of Queensland. In April 2017, a new pterosaur specimen was discovered on a property northeast of Winton, Queensland. This specimen, which comprises a partial skull with premaxillary and dentary crests, forty teeth, five cervical vertebrae, the majority of the left wing and fragments of the right wing, is the most complete pterosaur known from Australia, and the first reported from the Winton Formation (Cenomanian–lower Turonian) of the Eromanga Basin. All of the elements are three-dimensionally preserved, with their internal spaces filled by ironstone. Although the Winton pterosaur was discovered in a fragmented state in the bank of a normally dry ephemeral creek, it is likely that the skeleton was articulated prior to erosion: the upper and lower jaws were found articulated, and several wing elements key into matrix adhering to anatomically adjacent elements.

The inclusion of the Winton pterosaur in a phylogenetic analysis of Pterosauria resolved it within Anhangueria, specifically as the sister taxon to Mylitta camara (Australia). The new specimen differs from Mylitta in that the latter possesses more robust teeth. In contrast, the new pterosaur possesses a mandibular crest, and the mandible is distally expanded when compared with Austrosaurus. This Australian clade occupies the most derived position within Ornithocheiridae, with Ornithocheirus simus (United
Most anhanguerians derive from coastal or lagoonal paleoenvironments, and Laurasian/Gondwanan provincialism. Tropeognathus mesembrinus associated with phosphate-rich, high nutrient environments. Transitioning functional type from grasping-dominant Eocene taxa to cutting-dominant Oligocene taxa. Within the Miocene, there is a marked increase in Chondrichthyan taxa are poorly documented from Florida, despite their popularity, abundance, and utility for interpreting paleoecology. The Florida Museum of Natural History (FLMNH) has a curated collection of 103,364 chondrichthyan specimens spanning from the Eocene through the Pleistocene, and yet less than 1% of these have been published in peer-reviewed literature. Arguably, the two most profound climate events over this time span were the Eocene Oligocene Transition (EOT) and the Middle Miocene Climatic Optimum (MMCO). The EOT marks abrupt global cooling, with estimated ~2.5 °C drop in tropical sea surface temperatures. The MMCO represents a more prolonged global warming event, in which sea surface temperatures increased ~3–5 °C and atmospheric CO2 concentrations were comparable to today (~350–400 ppm). In the Eocene, lamniform sharks are the most diverse and abundant chondrichthyan; however, five genera of lamniform sharks go extinct at the Eocene–Oligocene boundary. In the Oligocene, carcharhiniform sharks become the most diverse and abundant chondrichthyan. This change in the dominant taxonomic group reflects a prominent transition in dental functional type from grasping-dominant Eocene taxa to cutting-dominant Oligocene taxa. Within the Miocene, there is a marked increase in chondrichthyan abundance (25% of FLMNH collection); which is well represented by a major radiation within the genus Carcharhinus, with first appearances of at least nine species. During the MMCO, there is little change in dental functional diversity; however, there is notably high chondrichthyan abundance. While this is in part a product of sampling bias, high abundance of chondrichthyan fossils during the MMCO is also reflected in other deposits (e.g., Shark Tooth Hill in Bakersfield, CA and Calvert Cliffs in Calvert County, MD), which has been attributed to increased primary productivity. Peak abundance of chondrichthyan taxa in Florida occurs during the Pliocene (70.1% of FLMNH collection), which is predominantly associated with phosphate-rich, high nutrient environments. Transitioning into the Pleistocene, as global climate continues to cool, chondrichthyan abundance decreases dramatically (3.6% of FLMNH collection); however, this may reflect sampling bias related to the fewer marine sites. This study documents local chondrichthyan diversity trends and sampling limitations, which are imperative for improving our comprehension of global diversity and projecting for future climate change.

Grant Information:
NSF Grant No. DGE-1315138 and DGE-1842473

Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)
ON THE PRESENCE OF A PUTATIVE ORNITHURAE (AVES) IN THE LATE MAESTRICHTIAN VERTEBRATE FAUNAS FROM SOUTHERN PYRENEES (SPAIN)
PÉREZ-PUENO, Manuel, Universidad de Zaragoza, Zaragoza, Spain; PUÉRTOLAS-PASCUAL, Eduardo, Geobiotec, Universidade Nova de Lisboa, Caparica, Portugal; MORENO-AZANZA, Miguel, Geobiotec, Universidade Nova de Lisboa, Caparica, Portugal; CRUZADO-CABALLERO, Pénlope, CONICET, Universidad Nacional de Río Negro, Roca, Argentina; GASCA, José M., Universidad de Zaragoza, Zaragoza, Spain; CANUDO, José L., Universidad de Zaragoza, Zaragoza, Spain

Remains of Late Cretaceous birds are scarce, especially in the Maastrichtian of Europe. Up to now, just some Eumaniornithes (e.g., Martinavis craczyensis) and Ornithurae remain have been recovered. In this context, one of the most remarkably remains corresponds to the giant bird Gargantuavis philoinos from the early Maastrichtian of France, unfortunately its phylogenetic position within Aves remains unknown. Here we present a carnivorous vertebra (MPZ 2019/264) belonging to a large-sized bird recovered from the upper Maastrichtian fossil locality ‘Dolor 3’ (Tremp Fm), near the village of Serraday within the Tremp Basin in the Pirenean range (Huesca, Spain). The Tremp Fm deposits from this area have been dated by magnetostratigraphy and biostratigraphy as belonging to the Chron C29r. Therefore MPZ 2019/264 is one of the youngest Mesozoic Aves of Europe, very close to the Cretaceous/Paleogene boundary (K/Pg), and the first of anhanguerians in the Tremp Basin. MPZ 2019/264 is an almost complete cervical vertebra just lacking the posterior articular face. The morphology of the anterior section of the vertebral centrum, which is concave transversely and convex dorsoventrally, confirms an advanced heteroscelous condition. In addition, a micro-CT analysis showed a very strong vertebral pneumatization with camellate internal structure. MPZ 2019/264 also bears two lateral pneumatic foramina in the neural arch and another one in the centrum. These foramina, along with a low and anteroposteriorly elongated neural spine and the arrow-shaped section of the centrum, differentiate MPZ 2019/264 from the cervical vertebra of Gargantuavis from Montplo-Nord (France). A cladistic analysis using a dataset comprising 23 ornithuromorphs, 29 enantiornithes and 8 basal avians, resulted in a well-supported placement of Gargantuavis is not included in the analysis, MPZ 2019/264 is recovered as member of Ornithurae. Nevertheless, these results have to be considered with caution, as the fragmentary condition of both Gargantuavis and MPZ 2019/264, and the lack of preserved unambiguous synapomorphies in the latter hinders further taxonomic attribution. In conclusion, the vertebra MPZ 2019/264 represents the second and youngest taxon of a Maastrichtian giant bird in the Iberian Armorican Island, adding new data to the scarce Aves fossil record of Europe during the last few hundred thousand years before the K/Pg extinction event.

Grant Information:
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Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM)
ANALYSIS OF ECOLOGICAL DIVERSIFICATION IN MARSUPIAL MAMMAL EVOLUTION BY MULTIVARIATE ANALYSES OF THEIR LIMB SKELETON IN BOTH EXTANT AND FOSSIL MARSUPLI

PEYSNER, Spencer K., University of Chicago, Riverside, CT, United States of America

Ecological diversification is an important aspect of the evolution of mammals. There have been many recent advances showing a broader ecological diversity for mammaliforma predecessors to mammals in the Mesozoic than had been previously thought. There have also been many recent studies on placental ecological diversity. However, the origin and ecological diversification of marsupials has not seen as much attention. This study took a quantitative approach to explain the origin of marsupial ecological diversification. This was done by compiling the largest dataset to date on skeletal measurements of extant marsupial species with known locomotor modes, with a small subset of this to dataset corroborated by CT scans. These measurements were used to calculate locomotor functional indices. Statistical significance of these indices was determined via ANOVA analyses. The statistically significant functional indices were then analyzed using a Principal Components Analysis and Linear Discriminant Analysis to associate the indices with locomotor modes. Analyses of these multivariate analyses show clear discrimination between locomotor modes, demonstrating that skeletal measurements can be informative about locomotor mode. When a fossil marsupial was placed into these analyses, it placed closely to the scarpnorial group, indicating that early marsupials were scalenorial. While this does not contradict previous qualitative analyses that early fossorial marsupials had arboreal skeletal adaptations, it does suggest that the evolution of locomotion in marsupials may not be a simple story of mammaliforma to marsupial transition. Further research is needed to better understand the origin of marsupial ecological diversification.

Grant Information:
Received the 2018 University of Chicago BSCD Ecology & Evolution Fellowship

Technical Session IX (Thursday, October 10, 2019, 2:00 PM)
FOSSIL AND EXTANT MORPHOLOGIES REVEAL REPEATED DEVELOPMENT OF DISTAL HINDLIMBS IN THE EVOLUTION OF SNAKES

PHANTRATANAMONGKOL, Waringorn (Minky), University of Cambridge, Cambridge, Cambridge, United Kingdom, HEAD, Jason, University of Cambridge, Cambridge, United Kingdom
Competing hypotheses of the interrelationships of Cretaceous snakes with well-developed hindlimbs require homoplasy in either the evolution of derived cranial characters or in the pattern of hindlimb reduction and loss in snake phylogeny. Specifically, a derived position of limbed snakes requires either multiple histories of limb loss in extant snake clades, or the ‘re-evolution’ of hindlimbs that include zeugopodial and autopodial elements in Cretaceous taxa. Retention of limb-patterning mechanisms during evolution of hindlimbs that include zeugopodial and autopodial elements in either multiple histories of limb loss in extant snake clades, or the ‘re-derived cranial characters or in the pattern of hindlimb reduct ion and loss in developmental modification in potential re-establishing limbs. Here we focus on fossil sampling biases or hidden molecular rate accelerations apparently more “primitive” faunas. Efforts to resolve this discrepancy have focused on calibrations for taxa that retain plesiomorphic taxa shifts the rate model errors deeper in the tree, inflating interordinal diversifications following the 66 Ma Cretaceous-Paleogene boundary mass extinction. This work was supported by Australian Research Council Discovery grants: DP10104659, DP170103227 awarded to M.J.P.

Preparators’ Session (Thursday, October 10, 2019, 2:30 PM)

COMPACTED FIBERGLASS ARMATURE FOR SUPPORTING SMALL FOSSIL SPECIMENS

PINSidorF, Michelle, Smithsonian Institution National Museum of Natural History, Washington, DC, United States of America

Armatures to support fossil specimens are commonly constructed with metals such as steel or brass. Metallic armatures can present risks for small and delicate fossil specimens, as repeated fit tests, abrasion, and metal corrosion can damage the fossil. An alternate armature material is here presented, made using stacked layers of fiberglass cloth which are saturated with Butvar B-76 adhesive liquefied in acetone, and compressed between sheets of Tyvek polyethylene cloth until set. The result is a stiff sheet of archival material which can be cut to size, adjusted in shape with the use of a liquid solvent, and adhered directly to the specimen if desired. The reversible properties of the adhesive used ensure that the armature can be removed in the future. This method is an adaptation of preexisting related techniques: using string temporarily adhered to segments of easily-fractured fossil, and using paper or fiberglass adhered to thin specimens as a supporting backing material. A drawback of this technique is the reduced force of the fiberglass armature when spanning large weights or across large surface areas. This method can be used not only in exhibit environments, but also in creating support structures which can be CT scanned along with the specimen, and for the removal of very fragile specimens.

A case study is presented using this method and materials to alter a historical display mount of the small mammal Leptomeryx evansi (USNM V16754) to provide support for fragile freely articulating limb bones. The use of this method reduced time needed in working with the specimen, avoided the use of equipment and hazards associated with welding or brazing, and avoided risk to the specimen associated with altering the original mount structure to properly anchor metal armature. Results of work include the greatly reduced likelihood of fracture and loss of limb elements, preserving the integrity of the specimen as both a display and research object.

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Exceptional coelurosaurian theropod dinosaur fossils provide astonishing insight into the evolution of theropod flight. Comparative morphology and different modelling approaches (such as physical models and aerodynamic equations) have documented a range of early flying strategies (including theropod flight). Laser-Stimulated Fluorescence (LSF) is a rapid, non-destructive geochemical imaging technique that has important applications in early theropod flight studies because it can visualise otherwise hidden flight-related anatomies exposed as fine geochemical differences in these fossils. LSF has so far revealed near complete soft tissue body outlines including of the wings and legs as well as propatagial feather follicle patterns in a small sample of select early theropod fossils and near-ears. Here we present LSF data from ~600 specimens of the short-tailed early bird Confuciusornis (Pygostyia: Confuciusornithidae) that for the first time reveals the soft tissue outline of the pectoral girdle and tail as well as subsurface details of the original propatagial muscle complex. We detect the form of the ancestral propatagial ligament, extensively muscled shoulders anchored to the well-known, unusually expanded deltopectoral crest of the humerus as well as reduced breast muscles associated with its sternum-less ventrum. Our results directly record a novel avian flight architecture that facilitates the classical avian flight abilities of coelurosaurs that appeared just short of entering the aerial realm. Laser-Stimulated Fluorescence fills knowledge gaps in functional morphology and flight capability.

**Technical Session VII (Thursday, October 10, 2019, 8:15 AM)**

**NEW JURASSIC AND CRETACEOUS NEOUSCHIANS FROM THE SAHARA ADD TO AFRICA’S REMARKABLE CROCODYLOID DIVERSITY AND ITS PALEOGEOGRAPHIC CONNECTIONS WITH NORTHERN LANDMASSES**

POL, Diego, Museo Paleontologico Egido Feruglio, Trelew, Argentina; SERINO, Paul C., University of Chicago, Chicago, IL, United States of America

New fossils discovered in Upper Jurassic and Cretaceous rocks in Niger and Morocco add significant diversity to the neosuchian record for Africa and additional complexity to its paleogeographic history. Jurassic forms include the first African gonionopholidids, two new genera from the Tournier Formation (? Middle Jurassic) of Niger. One is known from a complete skull that exhibits the classical form of the African clade and other cranial features highly reminiscent of Laurasian Goniohelys. The second gonionopholid has a narrow cranium and elongate snout, subdelted surface texture and spaced maxillary teeth of similar size. The gonionopholidids present another intriguing connection between Africa and Laurasia. There are three new Late Cretaceous (Cenomanian) genera in addition to new material of the bizarre flat-skulled neosuchian Loganocodon. The new forms include a large species known from nearly complete skulls. Synchrotron scanning of the gut contents has revealed abundant plant fossils within, thereby providing the first direct evidence of sauropod feeding habits in the fossil record. Lastly, a partial sauropod skull, associated with a hind limb, was discovered in 2018. Although it is still under preparation, it includes a braincase, quadrates, quadrategulae, a left squamosal, postorbitals, and several unprepared elements. Relatively few titanosauriforms are represented by cranial material, making this a critically important specimen that bridges the spatiotemporal gap between pre-Cenomanian titanosauriforms (e.g., Rapetosaurus, Euhelopus, Abyssosaurus, Taguia) and the Cenomanian–Turonian titanosaur Sarmentosaurus, and post-Turonian titanosaur forms such as Nigersaurus and Rapetosaurus. These new discoveries demonstrate the huge potential of the Winton Formation as a paleontological resource. Moreover, they greatly enhance our understanding of the postcranial skeleton—was unearthed in 2017. Preliminary analysis has enabled its referral to Diamantinasaurus; thus, the postcrania.

**NEW SAUROPOD DINOSAUR DISCOVERIES IN THE LOWER UPPER CRETACEOUS WINTON FORMATION (CENOMANIAN–LOWER TURONIAN) OF QUEENSLAND, AUSTRALIA: IMPLICATIONS FOR TITANOSAURIAN EVOLUTION**

POROPAT, Stephen F., Swinburne University of Technology, Hawthorn, Australia; MANNION, Philip D., University College London, London, England; UPCHURCH, Paul, University College London, London, United Kingdom; ELLIOTT, David A., Australian Age of Dinosaurs Museum of Natural History, Winton, Australia

The lower Upper Cretaceous Winton Formation (Cenomanian–lower Turonian), exposed near Winton, central Queensland, has produced a plethora of sauropod dinosaur specimens in the past decade. Three taxa have been established to date—Wintonotitan wattsi, Diamantinasaurus matildae and Savannasaurus elliotorum—and several recent discoveries promise to enhance our understanding of these taxa and of titanosauriform sauropods generally. The first sauropod footprints from the Winton Formation (discovered in 2016) demonstrate that at least one taxon was capable of adopting both relatively narrow- and wide-gauge stances, while retaining a prominent pollex ungual (previously hypothesised for Diamantinasaurus). This suggests that both gauge and presence/absence of a pollex ungual are problematic criteria for identifying titanosauroids from trackways. The hip height of one track-maker exceeded 2.6 metres, implying that body fossils of larger sauropods from the Winton Formation await discovery. The most complete sauropod skull ever found in Australia—comprising four teeth and much of the postcranial skeleton—was unearthed in 2017. Preliminary analysis has enabled its referral to Diamantinasaurus; thus, the postcrania.

**Technical Session XI (Friday, October 11, 2019, 11:45 AM)**

**THE ASSEMBLY OF CAT COMMUNITIES IN THE NEW WORLD: ECOMETRICS AND NEOGENE FAUNAL TURNOVER**

POLLY, P. David, Indiana University, Bloomington, IN, United States of America

Cats possess some of the highest ankle gear ratios of any extant carnivorans, a feature that facilitates leaping and sprinting involved in ambush predation and scanorial lifestyles. This paper addresses questions about the phylogenetic origin of their high ankle gear ratios and the history of their occupation of high gear ratio niches in the late Cenozoic of North America. Across all carnivorans it was found that gear ratios range from 1.08 (with extant ursids and viverrids and extinct miacids and barbouroufels having the lowest values) to 1.46 (with some felids and some machairodontines exhibiting very low gear ratios, emphasizing mechanical efficiency over advantage. The Miocene fields of North America did not occupy high gear ratio niches and, in fact, occupied some of the lowest gear ratio niches during the Barstovian, Clarendonian, and Hemphillian. A major restructuring of gear ratio distributions in North American carnivorans communities occurred during the Blancan that appears to have resulted from clad sorting processes involving the selective loss of low gear ratio groups.

**Technical Session XIV (Friday, October 11, 2019, 2:00 PM)**

**INTERNAL AND EXTERNAL FLIGHT-RELATED ANATOMY OF EARLY THEROPOD FLIERS REVEALED BY LASER STIMULATED FLUORESCENCE FILLS KNOWLEDGE GAPS IN FUNCTIONAL MORPHOLOGY AND FLIGHT CAPABILITY**

PITTMAN, Michael, The University of Hong Kong, Pokfulam, Hong Kong (CN); KAYE, Thomas G, Foundation for Scientific Advancement, Sierra Vista, AZ, United States of America; WANG, Xiaoli, Linyi University, Linyi City, China; ZHENg, Xiaoting, Shandong Tianyu Museum of Nature, Pengyi, China; HARTMAN, Scott A, University of Wisconsin Madison, Madison, WI, United States of America; XU, Xing, Institute of Vertebrate Paleontology and Paleoanthropology, Beijing, China

Cats possess some of the highest ankle gear ratios of any extant carnivorans, a feature that facilitates leaping and sprinting involved in ambush predation and scanorial lifestyles. This paper addresses questions about the phylogenetic origin of their high ankle gear ratios and the history of their occupation of high gear ratio niches in the late Cenozoic of North America. Across all carnivorans it was found that gear ratios range from 1.08 (with extant ursids and viverrids and extinct miacids and barbouroufels having the lowest values) to 1.46 (with some felids and some machairodontines exhibiting very low gear ratios, emphasizing mechanical efficiency over advantage. The Miocene fields of North America did not occupy high gear ratio niches and, in fact, occupied some of the lowest gear ratio niches during the Barstovian, Clarendonian, and Hemphillian. A major restructuring of gear ratio distributions in North American carnivorans communities occurred during the Blancan that appears to have resulted from clad sorting processes involving the selective loss of low gear ratio groups.
understanding of the evolution and ecology of Late Cretaceous Australian titanosauriform sauropods.

Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)

CRANIAL SUTURES AND MECHANICAL PERFORMANCE IN TETRAPOD SKULLS DURING THE WATER-LAND TRANSITION

PORRO, Laura B., University College London, London, United Kingdom; MAY, Julia R., University of York, York, United Kingdom; DUTEL, Hugo, University of Bristol, Bristol, United Kingdom; MARTIN-SILVERSTONE, Elizabeth G., University of Bristol, Bristol, United Kingdom; RAYFIELD, Emily J., University of Bristol, Bristol, United Kingdom

The emergence of tetrapods from the water and their conquest of the land was a key moment in the history of life marked by dramatic skeletal evolution. Changes in overall skull shape, a reduction in the number of bones, shifts in the size and distribution of the teeth, and presumed modifications in jaw muscle architecture are assumed to reflect new feeding mechanisms and diets, and/or differing environmental constraints. Experiments on living animals have demonstrated that sutures – fibrous joints between skull bones – impact the mechanical response of the skull to feeding forces, and different suture shapes are associated with tension, compression, or other load regimes. High-resolution micro-computed tomography was used to capture skull shape in fossil tetrapod skulls spanning the transition – from the Late Devonian to the Early Triassic – as well as in extant relatives. Suture shapes throughout the skull were documented and used to predict load regime. The predominance of orthoprismatic sutures in this sample suggests its variable load regimes in the skulls of Polypterus and tetrapodomorph fish such as Eusthenopteron. This may be related to a combined use of suction feeding and biting to capture and ingest prey, and/or hydrodynamic constraints imposed by an aquatic lifestyle. In contrast, the skulls of later stem tetrapods such as Acanthostega and Crassigyrinus exhibit interdigitated sutures associated with compression. Their distribution suggests forces being channelled from the teeth to the skull roof, consistent with load regimes generated by biting. After correcting for taphonomic damage and distortion, 3D reconstructions from CT data served as the basis for finite element models of the skulls of early tetrapods and their extant relatives. We compare skull mechanical response under simple feeding loads in finite element models to load regimes predicted by suture shape, including validation of model results using experimental data from living taxa.

Grant Information:
This research was funded by NERC Standard Grant NE/P013090/1 ("Skull evolution and the terrestrialization and radiation of tetrapods").

Technical Session I (Wednesday, October 9, 2019, 12:00 PM)

NEW WALRUSES FROM THE PURISIMA FORMATION REVEAL PATTERN OF HIGH LOCAL PINNIPED DIVERSITY IN THE MIO-PLIOcene EASTERN PACIFIC

POUST, Ashley W., University of California, Berkeley, Berkeley, CA, United States of America; BOESENECKER, Robert W., College of Charleston, Charleston, SC, United States of America; CURRIE, Philip J., University of Alberta, Edmonton, AB, Canada; CHURCHILL, Morgan, University of Wisconsin Oshkosh, Oshkosh, WI, United States of America; BOESENECKER, Sarah, College of Charleston, Charleston, SC, United States of America

The monotypic living walrus is only one highly-aberrant descendent of a much more diverse lineage, extending from at least the early Miocene (Burdigalian). Recent attention to vertebrate assemblages in the eastern North Pacific (ENP) has revealed a number with three or more odobenid taxa, including the Wilson Grove, Capistrano, and San Diego formations. We report two new taxa from the well-known Purisima Formation of north-central California, already one of the most diverse fossil odobenid assemblages. Both species are represented by relatively complete skulls. A new species of Valenictus is differentiated from V. chulavistensis by rostral and basioccipital features, in addition to its large size. This specimen clarifies previous reports of Valenictus sp. in the formation and further distinguishes the fauna from later and more southern assemblages characterized by other members of the genus. The second new walrus belongs to the genus Gomphotaria, showing differences in tooth number and tooth-row orientation among other features. The description of this large lungfish confirms the presence of at least five walrus taxa, with two currently unique to the Purisima Fm. Inclusion of these new taxa within a phylogenetic analysis yields several important results including the recognition of a monophyletic Dusignathinae (including the new species) and the recovery of Plopadenia as sister to Valenictus. The combination of these walruses, Callorhinus and an indeterminate otariid is distinct from the extant, walrus-free pinniped fauna of several eutardas and 2 phocids. The diversity of the Purisima Fm. walruses suggests that these multi-taxon communities may represent the rule during the Mio-Pliocene. A greater degree of faunal endemism in the ENP is indicated by the recognition of these new distinct species, an effect that would likely be magnified by comparison with other regions, such as the western North Pacific or northern Atlantic.

This increased inter-basin provinciality provides support for theories linking the Late Miocene peak in odobenid diversity with the effects of marine regression on reproductive isolation of previously connected populations. As more assemblages with multiple fossil walrus taxa are recognized we should move from seeking the “most diverse” towards exploring the patterning of pinniped communities across the basins of the Eastern Pacific preceding the Plio-Pleistocene boundary and subsequent loss of odobenid diversity.

Regular Poster Session I (Wednesday, October 9, 2019, 4:15 - 6:15 PM)

DISCRETE VARIATION IN MAXILLAE OF EUDROMAEOSAUR DINOSAURS AND ITS RELATION TO TRENDS IN SNOT MORPHOLOGY

POWERS, Mark J., University of Alberta, Edmonton, AB, Canada; CURRIE, Philip J., University of Alberta, Edmonton, AB, Canada

During the Late Cretaceous, dromaeosaurids filled the small to medium-sized predator niche with a nearly global distribution. The most iconic of these “raptor” dinosaurs are the Eudromaeosauria, a clade of dromaeosaurids that excludes microraptorines and unenlagiines. This group is largely represented by taxa from Asia and North America, predominantly Velociraptor and Deinonychus respectively. Other eudromaeosaur taxa are known from partial material, some as few as single elements. Among these elements the maxilla has been given a lot of taxonomic weight. In the description of early North American species, represented by maxillae and some associated material, researchers have noted two potential morphotypes. Asian taxa tend to be long-snouted whereas North American taxa are usually short-snouted. Some authors have proposed taxonomic relationships relating to the elongation of the snout. Whether these variations are valid homologous characters, or convergent similarities due to ecological pressures is unsettled. Proportional characters have the problem of often being ambiguous and difficult to code, therefore careful, critical examination of the data is essential for determining the significance of these characters and their states.

Up to 14 measurements were taken from 15 maxillae across 10 recognized species to look for distinct groupings within the range of data. Both bivariate and multivariate analyses were used to identify these distinct groups with a focus on proportions relating to elongation of the maxilla and its various features. In comparison with complete skull and femoral lengths, the Asian taxa have longer, lower snouts, whereas the snouts of most North American taxa are shorter and deeper. Distinct groupings also exist between Asian and North American taxa based on the length/height ratios of the maxillae. The length/height ratio of the lateral lamina of the maxilla shows a similar dichotomy, however, the North American taxon, Acheroraptor, has lateral lamina proportions like the Asian taxa. However, the proportions of the maxilla in this taxon is closer to its North American relatives, which suggests that the elongation of the lateral lamina can occur separately from the elongation of the snout. North American taxa appear to have had stronger bite forces than their Asian relatives, although the latter could close their jaws more rapidly. This implies some fundamental ecological differences between eudromaeosaurans on the different continents during the Late Cretaceous.

Grant Information:
Natural Sciences and Engineering Research Council of Canada Dinosaur Research Institute Student Project Grant

Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)

TAPHONOMIC CHANGES OF EARLY MIDDLE PLEISTOCENE STEGodon BONE ASSEMBLAGES FROM FLORES, INDONESIA

POWLEY, Meagan J., University of Wollongong, Wollongong, Australia; VACHS, DEN BERGH, Gerrit, Binnendijk Wielink, Amsterdam, Netherlands; POWLEY, Meagan J., University of Wollongong, Wollongong, Australia; KURNIAWAN, Iwan, Museum Geologi Bandung, Bandung, Indonesia; SUTISNO, Indra, Museum Geologi Bandung, Bandung, Indonesia

A fossil Stegodon bone assemblage from an early Middle Pleistocene fluvial sandstone layer in the So’a Basin on the Indonesian island of Flores, were analyzed in order to identify and differentiate fresh post mortem fractures from other fractures. The layer of interest has yielded stone artefacts as well as hominin remains, but to date there has been no proven evidence that hominins were involved in the accumulation of remains of Stegodon or other vertebrates. The total surface area excavated from this layer between 2013 and 2018 is approximately 239 m². The in situ coordinates of the total 17,238 excavated fossil specimens were recorded using a Total Station. Of these specimens, 55% has been identified to at least Class level. This study focuses on two subsamples from the Mata Menge assemblages. The first subsample...
concentrates on the limb bones of Stegodon (n=18), the second represents all vascular fossils from a 1 x 1 m area (n=99).

Both subsamples comprise complete and fragmented bones. The examination of the fossilised remains focused on the impact of both biological and physical taphonomic agents. Macroscopic inspection and examination under a binocular microscope were employed, to determine post mortem bone modifications using a set of five criteria. These criteria focused on the size of the bones and bone fragments as well as the types and shapes of fractures and marks on the fossilised bones.

A majority of the limb bones were broken and reduced at both the distal and proximal ends of the bones. A significant number of the bones also had evidence of excavation damage. Preliminary findings from this surface examination suggest little evidence of deliberate cut marks or fresh fracturing on the Stegodon limb bones.

There were also indications for a significant amount of reworking of bones prior to final burial, as some bones from the 1 x 2 m concentration had evidence of intermittent dry bone breakage over time and reduction in size, emergent vegetation and both standing and flowing waters. Anasid are common but not diverse and dominated by larger taxa; their widespread presence suggests extensive, mature wetlands and wet meadows. Higher, drier grounds capable of supporting trees would have been present for heron, ibis, cormorant, owl, and other roosting birds. The inferred habitat requirements of these Pliocene birds support other environmental proxies preserved here that are indicative of lake, wetland, and riverine environments. However, these fossil occurrences are spread across 17.6 km² and span close to one million years of palaeontological history.

Here, the Hagerman Palaeontology, Environments, and Tephrochronology (PET) Project considers distributions of these birds within and across three major depositional units (Units I-III) to better reconstruct spatial-temporal changes in the Hagerman avifaunal community between approximately 4.0 and 3.07 Ma. Recently-accumulated taphrochronology and taphrostratigraphy data, in conjunction with geospatial data of fossil bird occurrences, show that bird communities vary in composition and occurrence across and within these three roughly defined time slices or geolandscape. For example, highest species richness and greatest habitat breadth, with birds indicative of wetland, woodland, and grassland environments, occurs in the eastern portion of Bed II and the southern end of the upper portion of Bed III. Such results provide data on the effects of a changing environment on avifaunal composition and distribution and a more accurate reconstruction of these ancient landscapes at Hagerman.

Symposium: Quarterary Extinctions (Friday, October 11, 2019, 4:00 PM)
ECOLOGICAL FALLOUT AND TURNOVER IN THE DIVERSITY OF LATE QUATERNARY TERRESTRIAL PREDATORS OF AUSTRALIA

PRICE, Gilbert J., The University of Queensland, Brisbane, Australia; LOUVS, Julien, Griffith University, Brisbane, Australia; SOBBIE, Ian H., The University of Queensland, Brisbane, Australia; RISTEVSKI, Jorgo, The University of Queensland, Brisbane, Australia; MOLNAR, Ralph E., University of California Museum of Paleontology, Berkeley, CA, United States of America.

Australia’s fossil record shows that its modern ecosystems are not analogous to those of the recent past, especially in terms of the variety and diversity of terrestrial predators. Modern ecosystems are largely dominated by mammalian carnivores including the Dingo (Canis familiaris), cat (Felis catus), and fox (Vulpes vulpes). Some researchers have previously contended that Australia’s late Pleistocene terrestrial predator guild was also dominated by mammals, principally two species of marsupial ‘lion’ (Thylacoleo spp.; 30-130 kg), two species of marsupial ‘devil’ (Sarcophilus spp.; 5-30 kg), and the Thylacine (Thylacinus cynocephalus; 15-30 kg). However, recent fossil records from northern and eastern Australia significantly challenge that assertion. Here we present new data on the reptilian terrestrial predator guild of the late Pleistocene. Our integrated field and geochronological studies have produced the continent’s youngest fossil record of giant monitor lizards (Varanus priscus; 80-200+ kg) dating younger than 50 ka. Indicative dating of the type locality of the terrestrial ziplodont crocodile Quinkana fortirostrum (40 kg), suggests it may also be late Pleistocene. We also here report the discovery of another new genus and species of an unequivocal late Pleistocene terrestrial crocodile (250 kg). Coupled with fossil records from elsewhere that shows at least three species of giant monitor lizards were present during the late Pleistocene (70-250 kg), along with a giant snake (Wonambi naracoortensis; 150 kg), the large-bodied terrestrial predator guild of ‘Ice Age’ Australia was clearly dominated by reptiles. Their extinction, along with that of marsupial ‘lions’ in the late Pleistocene, left the Thylacine and modern ‘Tasmanian’ Devil (S. harrisii; 5-12 kg) as the largest (non-human) terrestrial predators until the middle Holocene. The introduction of the similarly sized but apparently more ecologically efficient Dingo (20-25 kg) around 4 ka was immediately followed by the mainland extinction of the Thylacine and Devil likely as a result of competition. In the absence of larger-bodied predators that could have potentially applied ecological suppression, the Dingo thrived and became particularly widespread. Cats and foxes subsequently filled the role of the small-bodied mesopredators of Australia following their introduction by Europeans in the late 18th century. Collectively, these new data demonstrate a major ecological and biological shift from reptile- to mammal-dominated terrestrial predators of the continent.

Grant Information:
Australian Research Council grants DP120101752 and DE120101533.
Symposium: Origin of a Sunburnt Country (Saturday, October 12, 2019, 9:45 AM)
VERTEBRATE RESPONSES TO PLEISTOCENE ENVIRONMENTAL CHANGE IN SOUTH-CENTRAL AUSTRALIA

PRIDEAUX, Gavin J., Flinders University, Adelaide, Australia; CRICHTON, Arthur I., Flinders University, Adelaide, Australia; SHUTE, Elen R., Flinders University, Adelaide, Australia; NGUYEN, Jacqueline M., Australian Museum, Sydney, Australia; ARNOLD, Lee J., University of Adelaide, Adelaide, Australia; PILLANS, Bradley J., Australian National University, Canberra, Australia.

The Nullarbor Plain is a sparsely-treed expanse of arid shrub steppe in south-central Australia, which today acts as an arid barrier to the east-west dispersal of many mescic species. However, varying levels of relatedness expressed by southwestern and southeastern taxa suggest a complex history of interconnectedess across this region during moister intervals. The discovery in the early 2000s and subsequent palaeontological analysis of the Thylacoleo Caves, a trio of caves in the center of the Nullarbor Plain, is providing a window onto the previously poorly-understood Pleistocene fauna and environmental history of this region. Here we report on changes in vertebrate species composition and relative abundances through a 1.5-m deep sequence of infill sediments in one of these sites, Leaena’s Breath Cave. From an analysis of around 17,000 taxonomically-identifiable specimens, we recognize a total of 151 species composed of 41 mammals, 81 birds, 26 squamates and 3 frogs. This makes Leaena’s Breath Cave by far the most species-rich Pleistocene vertebrate deposit on the continent. The assemblage accumulated via a mixture of pitfall trapping and avian predators, including owls. Although the reversed magnetic polarity of sedimentary Unit 3 has been interpreted as indicating deposition during the early Pleistocene, luminescence dating of both quartz and feldspar grains suggests that the entire sequence was deposited during the middle Pleistocene. This raises the possibility that Unit 3 accumulated during one of the brief magnetic excursions within the Brunhes Chron. Distinct temporal trends are expressed by species that, in modern times, are: 1) associated with open habitats; 2) generally associated with trees; and 3) explicitly dependent on trees. Cluster analysis allows us to infer that the Leaena’s Breath Cave sequence accumulated across four climatic phases marked by vegetation that varied from predominantly closed woodland to chenopod shrubland.

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AN UNUSUAL NON-SAUROLOPHID ‘DUCK-BILLED’ DINOSAUR FROM THE EARLY CAMPAIGN (TERTIACEOUS) OF OHIO. PECOS, TEXAS AND THE ANCESTRAL HASRODUSIAN CREST

PRIETO-MARQUEZ, Albert, Institut Catala de Paleontologia, Sabadell, Spain; WAGNER, Jonathan R., Buda, TX, United States of America; LEHMAN, Thomas M., Texas Tech University, Lubbock, TX, United States of America

The Aguja Formation of West Texas preserves one of the southernmost Campanian terrestrial vertebrate faunas in North America. Here we report on an unusual hadrosaurid dinosaur specimen from the lower shale member of the Aguja Formation (lower Campanian) of Big Bend National Park. This animal is uniquely positioned phylogenetically and temporally to expand our understanding of the early evolution of the hadrosaurids supracranial ornamentation, adding to our understanding of the early evolution and diversity of the clade. This taxon is characterized by autapomorphies of the facial skeleton and mandible, including a crest composed of broadly arched nasals similar to that of kritosaurids. The symphysial processes are elongated and reflected dorsally, causing the dentaries to meet with a w-shaped anterior profile, and this skull appears to be unusually broad for a hadrosaur. A hypothesized shovel-shaped prefrontal may have been used in excavating and scooping up semi-aquatic vegetation. This animal was previously attributed to Kritosaurus und is otherwise superficially similar to Gryposaurus. However, it differs from saurolophids in retention of key plesiomorphic character states in the maxilla and jugal. Phylogenetic analysis reveals this hadrosaurid to be a non-sauropolid (i.e., outside of Saurolophinae + Lambeosaurinae) hadrosaurid allied to Antarctosaurus from the late Campanian of Mexico, which bears a similar, broadly-arched nasal. The recognition of this lineage points to the existence of a hitherto unknown diversity of “duck-billed” dinosaurs outside of the saurolophine-lambeosaurine radiation, previously restricted to Hadrosauridae and Trachodon (Campanian of New Jersey) and Eotrachodon orientalis (Campanian of New Jersey). Our results suggest that arcas and their living environments of Java has become available over the past 200 years and their position within Placentia, remain contentious. The Periptychidae are a clade of distinctive “archaic” ungulates, composed of ~17 genera of small to large bodied, highly bonyodont, terrestrial herbivores that were among the first placental mammals to appear after the end-Cretaceous mass extinction. Although the Periptychidae has been historically considered a distinctive “condylarth” subgroup, their higher-level relationships have been rarely tested. Here, we present an inclusive cladistic analysis to determine and test the phylogenetic affinities of Periptychidae and other key Paleocene groups within Placentia under different clastic optimality criteria. We scored 140 taxa for 503 dental, cranial and postcranial characters, incorporating new morphological and taxonomic data. The data were then subject to parsimony and Bayesian searching protocols. For the Bayesian analysis we employed a Mk + Γ model of morphological evolution, running 500000 generations with samples every 200 generations and discarding 25% of the samples as burn-in. Stationarity was achieved and a 50 percent majority rule consensus tree from the sampled trees was obtained. The parsimony analysis recovered 43 most-parsimonious trees. The two consensus trees derived from the different analyses are largely congruent and recover a monophyletic Periptychidae, although the parsimony consensus tree is better resolved. These results are consistent with simulation studies showing that parsimony tends to be more precise (more nodes reconstructed) than Bayesian analyses, although less accurate. The main topological differences between the results relate to the position of poorly known Puerca (earliest Paleocene) species. Our results affirm the monophyly of Periptychidae and its nesting within a group of “condylarths” positioned at the base of Laurasia and closely related to Artiodactyla. Within Periptychidae we found support for the three major subfamilial divisions in both analyses. These results highlight the importance of using different optimality criteria when resolving a phylogeny and provide a new insight into how placental mammals were evolving after the end-Cretaceous extinction.

Grant Information:
Australian Research Council Future Fellowship grant FT130101728; National Geographic Research and Exploration grant 88736-10

Regular Poster Session III (Friday, October 11, 2019, 4:15 - 6:15 PM)

TESTING THE PHYLOGENY OF PERIPTYCHIDAE AND “ARCHAIC” PALEOCENE MAMMALS UNDER DIFFERENT OPTIMALITY CRITERIA

PÜSCHEL, Hans P., University of Edinburgh, Edinburgh, United Kingdom; SHELLEY, Sarah L., Carnegie Museum of Natural History, Pittsburgh, PA, United States of America; WILLIAMSON, Thomas E., New Mexico Museum of Natural History, Albuquerque, NM, United States of America; WIBLE, John R., Carnegie Museum of Natural History, Pittsburgh, PA, United States of America; BRUSATTE, Stephen, University of Edinburgh, Edinburgh, United Kingdom

It is now well established that the end-Cretaceous mass extinction had enormous repercussions for mammalian evolution. Following the extinction, during the Paleocene, mammals started to radiate, occupying new and diverse ecological niches. However, the phylogenetic relationships between the so-called “archaic” mammals of this time, and their position within Placentia, remain contentious. The Periptychidae are a clade of distinctive “archaic” ungulates, composed of ~17 genera of small to large bodied, highly bonyodont, terrestrial herbivores that were among the first placental mammals to appear after the end-Cretaceous mass extinction. Although the Periptychidae has been historically considered a distinctive “condylarth” subgroup, their higher-level relationships have been rarely tested. Here, we present an inclusive cladistic analysis to determine and test the phylogenetic affinities of Periptychidae and other key Paleocene groups within Placentia under different clastic optimality criteria. We scored 140 taxa for 503 dental, cranial and postcranial characters, incorporating new morphological and taxonomic data. The data were then subject to parsimony and Bayesian searching protocols. For the Bayesian analysis we employed a Mk + Γ model of morphological evolution, running 500000 generations with samples every 200 generations and discarding 25% of the samples as burn-in. Stationarity was achieved and a 50 percent majority rule consensus tree from the sampled trees was obtained. The parsimony analysis recovered 43 most-parsimonious trees. The two consensus trees derived from the different analyses are largely congruent and recover a monophyletic Periptychidae, although the parsimony consensus tree is better resolved. These results are consistent with simulation studies showing that parsimony tends to be more precise (more nodes reconstructed) than Bayesian analyses, although less accurate. The main topological differences between the results relate to the position of poorly known Puerca (earliest Paleocene) species. Our results affirm the monophyly of Periptychidae and its nesting within a group of “condylarths” positioned at the base of Laurasia and closely related to Artiodactyla. Within Periptychidae we found support for the three major subfamilial divisions in both analyses. These results highlight the importance of using different optimality criteria when resolving a phylogeny and provide a new insight into how placental mammals were evolving after the end-Cretaceous extinction.

Grant Information:
CONICYT PFFCA/DOCTORADO BECAS CHILE/2018, European Research Council Starting Grant (ERC SIG 2017, 756226, PalM), National Science Foundation (NSF EAR 1654952, DEB 1654949)

Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)

GEOLOGICAL AND PALEONTOLOGICAL ASPECTS OF A NEW EARLY – MIDDLE PLEISTOCENE TERRESTRIAL VERTEBRATE FOSSIL-BEARING SITE IN WEST JAVA, INDONESIA

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A wealth of information from paleoecologic, paleoenvironmental and paleoecological studies in relation to the evolution of vertebrate fossil fauna and their living environments of Java has become available over the last two decades. However, this information is heavily based on discoveries from Central and East Java and does not significantly represent fossil faunas of West Java. This is due to the fact that the paleontological research in West Java is a lot more lacking than those in East Java. Vertebrate fossil studies represent West Java were so far still lags far behind although this area is a key area to reconstruct a more comprehensive paleoecology of Sundaland during the Quaternary. The attempts to use fossil faunal assemblages from West Java in regional paleoenvironmental reconstructions and studies on faunal evolution are hampered by the limited faunal record, the lack of accurate
dates, and the mixed nature of faunal assemblages. Therefore, additional empirical data of fossil records and its stratigraphic context are critical for understanding the chronology, evolution, and environmental conditions during the early occupation of terrestrial habitat of Java. In this study, our study focused in a fossil-bearing site located in Cisarua River, Batangas, Majalengka, West Java. In order to establish the context of the study area, we performed systematic surveys in the Citalang Formation along the Ci Saar River and its tributaries. We also conducted two test excavations and collected fossil from the surface. During the preliminary study, we recorded vertebrate fossil assemblage, including: *Bubalus paleolarcarbuns*, cervids, *Stegodon trigonocephaus*, suids, crocodile and carnivores. The vertebrate fossils in this area could be associated with the Early to Middle Pleistocene *Ci Saat and Kedungbrubus* Faunas in the Java vertebrate biostratigraphic scheme. We also unearthed a pair of Stegodon tusk from the black clay facies of the Early Pleistocene Citalang Formation. The tusk length reached 3.2 m, which are the longest and most complete Stegodon tusk material from West Java, and probably from Java. The tusk most likely belong to a primitive Stegodon lineage. Further result and implication will be discussed in the presentation.

Grant Information: This research is funded by Institut Teknologi Bandung and LAPI ITB.

Technical Session VII (Thursday, October 10, 2019, 11:00 AM)

FILTER FEEDING IN LATE JURASSIC PTEROSAURS SUPPORTED BY COPROLITE CONTENTS

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Pterosaurs first appeared in the Late Triassic and constituted thereafter an important part of Mesozoic ecosystems until the end-Cretaceous mass extinction. Their diets, however, have hereto only been inferred from functional morphology, rare gut contents, and single coprolite with enigmatic inclusions. We have described three coprolites found on a surface with abundant pterosaur tracks from early Kimmeridgian intertidal deposits of the Wierzchica Quarry in Poland. The morphology of the coprolites, and their association to the tracks, indicate a pterosaur producer. Synchrotron scans revealed that the coprolites are rich in foraminifera and other small remains including bivalves, ostracods and bristles (some possibly from polychaete worms). The high density of these shelly inclusions suggest that they were not accidently ingested but constituted an important food source for the pterosaurs, perhaps along with unsupervised-soft-bodied animals. The combined evidence from the coprolites and tracks suggest filter-feeding ctenochasmatids as the most likely trace-makers. If true, this significantly expands the biological record of this pterosaur group (previously known only from gastroliths). It also represents the first direct evidence of filter feeding in Jurassic pterosaurs and demonstrates that their diet was similar to that of the recent Chinese flamingo* (*Phoenicopterus chloris*).

Symposium: Quaternary Extinctions (Friday, October 11, 2019, 3:00 PM)

NEOLITHIC HUMAN-INDUCED EXTINCTION OF PREVIOUSLY UNRECOGNIZED GIANT TESTUDINID TORTOISES ENDEMIC TO MELANESIA

RABI, Marton, Martin-Luther-University Halle-Wittenberg, Halle (Saale), Germany; WORTHY, Trevor H., Fliinders University, Adelaide, Australia; HAWKINS, Stuart, Australian National University, Canberra, Australia; BEDFORD, Stuart, Australian National University, Canberra, Australia; SPRIGGS, Matthew, Australian National University, Canberra, Australia

The Melanesian islands of Vanuatu and Fiji have yielded archeological remains of the large extinct terrestrial turtle *Megalanis damelii* dated to 3000-2500 BP. These turtles were hunted by the Neolithic Lapita culture and are considered to represent the last surviving representatives of the stem-turtle lineage Melanidae, a clade including bizarre, horned, ankylosaur-like turtles widespread in the Cenozoic record of Patagonia, Australia and multiple Oceanic islands. However, the melanid turtles of the Vanuatu turtles have been disputed. New cranial remains, as well as a review of all available skeletal elements, now allow us to clarify the systematic affinities of this turtle. The material includes mostly limb and girdle bones, some shell fragments, and few cranial elements. The extensive upper and lower temporal emargination, the medially contacting prefrontals, the deep skull and lower jaw, the flattened centra of the cervical vertebrae, the presence of quadrangular neurals, the cartilaginous epipubis, and the proportions of the appendicular skeleton undoubtedly identify a testudinid. Testudinidae (commonly referred to as tortoises) is a globally distributed clade of terrestrial turtles which are known for their high dispersal abilities to islands (e.g., Galapagos tortoises). Yet the presence of testudinids in Vanuatu and Fiji represents a major biogeographical enigma because the nearest living or extinct tortoises are 5300 km far. On the other hand, the South Equatorial Current flowing westward from South America and the Galapagos islands branches off southward right between Fiji and Vanuatu which may have facilitated an extreme dispersal. The material from Vanuatu and Fiji is too fragmentary for resolving the phylogenetic position within Testudinidae but given that there are no comparable extinct forms known from Southeast Asia or Oceania we exclude the possibility of human introduction. Instead, the remains clearly indicate a yet unrecognized extinct Melanidae clade of giant island tortoises—the largest reptiles exterminated by humans in the area. The presence of numerous autopomorphic morphologies suggests a not too recent divergence from other testudinids and highlights the potential for discovering many other subfossil groups. In particular, crocodiles are relatively poorly known, yet likely had an interesting evolutionary history. Late Cretaceous crocodilians from Madagascar include more than seven different taxa. Subfossil crocodilians from the Late Pleistocene and Holocene do not appear to be descendants of these clades, and include two genera: the extinct *Voay robustus* and living *Crocodylus niloticus*. However, we do not know much about their geographic range, whether they lived at the same time and competed with each other in the same habitats, or the types of environments that they preferred. We present here a description of subfossil crocodile bone from the Central Highlands of Madagascar: *Tsaramody* (Sambaina Basin) - a newly discovered subfossil site that samples a wetland environment, and represents the highest-altitude known subfossil site on the island (1655 m). Both skull elements and postcranial elements are described. Subfossil crocodilians from *Tsaramody* appear morphologically different from those at other nearby sites (e.g., Ampasambazimba) as well as those recovered from the southwest (e.g., Tsimanampetsotsa), and suggests that the species boundaries between these taxa may be more complex than previously thought. A better understanding of Malagasy subfossil crocodilian taxonomy, as well as their past geographic and temporal ranges has great potential to elucidate their evolutionary history on the island, and the details of their extinction.

Grant Information: National Geographic (#8667-09); Fulbright African Regional Research Program

Regular Poster Session I (Wednesday, October 9, 2019, 4:15 - 6:15 PM)

REPTILE DIVERSITY OF MCEACHERN’S CAVE, A LATE PLEISTOCENE TO HOLOCENE FOSSIL DEPOSIT FROM VICTORIA, AUSTRALIA

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Australia comprises more reptile species than any other country on earth; however, the fossil record of Australian reptiles is poorly studied. This is
especially evident in Victoria, where, despite the presence of well-preserved fossil deposits, fossil reptiles have never been examined. Here we present the first faunal list of Victorian reptiles from McEachern’s Cave, a Late Pleistocene to Holocene fossil deposit. This site is located in the Lower Glenelg National Park and features a well-defined stratigraphy as well as consistent dating. Furthermore, the site was already studied in terms of mammal remains, revealing the presence of several megafauna mammals like e.g., giant wombats. For the present study, original cave material was sorted for reptile remains, unveiling a rich reptile fauna, especially within the Holocene deposits. Reptile remains were assigned to different species or morphotypes using qualitative features and reference skeletons of extant species. The fossil fauna seems to be similar to the present day fauna and is dominated by species of Scincidae and Elapidae. A remarkable find is a single pygopodid jawbone, which probably belongs to Delma sp., a genus that does not occur in the area today. Closely related extant species are strongly associated with grassland ecosystems and therefore the fossil could indicate the presence of grassland in the area surrounding McEachern’s Cave at ~7ka.

In general, reptiles generally represent the present distribution of some squamate taxa and are therefore crucial to determine the effects of agricultural land modification on Australia’s herpetofauna. The information from these recent fossil deposits can then be used to create baseline data to evaluate the current conservation status of different reptile species.

Grant Information:
Till Ramm was supported during this work by a doctoral scholarship of the German Academic Scholarship Foundation (Studienstiftung des deutschen Volkes).

Regular Poster Session I (Wednesday, October 9, 2019, 4:15 - 6:15 PM)
A NEW LATE PLEISTOCENE SUBFOSSIL SITE (TSARAMODY, SAMBAINA BASIN, CENTRAL MADAGASCAR) WITH IMPLICATIONS FOR THE CHRONOLOGY OF HABITAT AND MEGAFAUNAL COMMUNITY CHANGE ON MADAGASCAR’S CENTRAL HIGHLANDS
RASOLOFOMANANA, Nadia T., University of Antananarivo, Antananarivo, Madagascar; SAMONDS, Karen E., Northern Illinois Univ, Dekalb, IL, United States of America; CROWLEY, Laurie R., University of Massachusetts, Amherst, MA, United States of America; ANDRIAMBELOMANANA, Miora Christelle, University of Antananarivo, Antananarivo, Madagascar; ANDRIANAVALONA, Tsoty H., University of Antananarivo, Antananarivo, Madagascar; RAMHANGIHAISON, Naiana T., University of Antananarivo, Antananarivo, Madagascar; RAKOTOZANDRY, Ravoniana B., University of Antananarivo, Antananarivo, Madagascar; NOMENJAHARY, Botossemily Z., University of Antananarivo, Antananarivo, Madagascar; IRWIN, Mitchell, Northern Illinois University, Dekalb, IL, United States of America; CROWLEY, Brooke, University of Cincinnati, Cincinnati, OH, United States of America;

Madagascar is a complex “biodiversity hotspot” with a rapidly dwindling biota. The Late Quaternary subfossil record includes many extinct species whose loss is attributed to natural climate change and human impacts. Investigation of the chronology of these extinction events is challenging because few localities document pre-Holocene communities not impacted by humans. Caves with extensive lems of large body size comprise some of Madagascar’s richest subfossil sites, but they provide only a limited window into the island’s past. Open highland sites have fewer primate, but they better document other megafauna, and allow the analysis of the role of the Central Highalnds as refugia, and as corridors for the dispersal of vertebrates before and after human arrival. Here we present a new subfossil site, Tsaramody (Sambaina basin, central Madagascar), a high-altitude wetland area that preserves a vibrant late glacial and postglacial vertebrate community. Tsaramody bears testimony to fluctuations in the highland flora during the transition from glacial to postglacial conditions, and the composition of a highland vertebrate community before humans arrived. We compare its biota to those of other sites to begin to document the decline and disappearance of some of Madagascar’s most neglected, but perhaps most important, ecosystems – wetlands dominated by hippopotamuses, crocodilians, and elephant birds.

Technical Session V (Wednesday, October 9, 2019, 4:00 PM)
EXTINCT BIRDS OF NEW ZEALAND: HOW ANCIENT DNA AND MORPHOLOGY IS RAPIDLY INCREASING THE NUMBER OF HUMAN DRIVEN EXTINCTIONS
RAWLENCE, Nicolas J., University of Otago, Dunedin, New Zealand

The arrival of humans in Aotearoa New Zealand resulted in the loss of 50% of its unique biodiversity due to hunting, habitat destruction and predation by introduced predators. New Zealand is unique in that the often confounding effects of humans and climate change can be clearly separated, and studied in isolation. The arrival of humans and the consequent extinctions occurred at a time of relative climatic stability. New Zealand's rich Late Quaternary fossil record, spanning the past 60,000 years, and the recent archaeological record, contain the remains of many of New Zealand's extinct avian species. The advent of ancient DNA, combined with morphological analysis, has revolutionised our understanding of New Zealand's extinct avian biodiversity. The current rate of discovery of extinct Late Quaternary birds in New Zealand is unprecedented, with several new species described since 2009. This talk will highlight several of these new taxa including the Kohatu Shag (Leucoarao septentrionalis), Pouwa (Cynips sumnerensis), Waitaha Penguin (Megadyptes antipodes waitaha), Richdale's Penguin (M. antipodes richdalei) and Warham's Penguin (Eudyptes warhamii). These discoveries challenge our understanding of the vulnerability of insular island fauna, and consequent biological turnover events, and have implications for 're-wilding' ecosystems and how conservation paleontology can inform the management of threatened species.

Grant Information:
Royal Society of New Zealand Marsden Fund and the University of Otago

Technical Session VI (Thursday, October 10, 2019, 8:00 AM)
FOSSIL RECORD OF THE SOUTHERN BENT-WING BAT (MINIOPTERUS ORIANAE BASSANI) FROM QUERNARY DEPOSITS AT NARACOORTE CAVES, SOUTH AUSTRALIA: IMPLICATIONS FOR CONSERVATION OF A CRITICALLY ENDANGERED SPECIES
REED, Elizabeth H., University of Adelaide, Adelaide, Australia

Quaternary fossil deposits of the Naracoorte Caves National Park (NCNP) are World Heritage listed for their record of vertebrate faunas spanning at least the past 500,000 years. The Naracoorte faunal assemblages are dominated by mammals and much of the previous paleontological research has focused on marsupials. Despite being a key element in the extant faunas of the region, the fossills bats have never been studied in depth. Currently, there are 17 bat species living in the South East region of South Australia. At least two have been observed at Naracoorte. The Naracoorte Caves National Park (NCNP) is a significant breeding and roosting site for the Southern Bent-wing Bat (Miniopterus orianae bassani). This species is listed as Critically Endangered under the Commonwealth EPBC Act due to population decline and reliance on only three breeding sites (Bat Cave at Naracoorte, Starlight Cave at Warrambool and a site at Portland). Habitat clearance, human activities, invasive species and climate change have all been considered as contributors to decline. Teasing apart the discrete impacts of these factors is critical for developing appropriately targeted recovery strategies. Long-term data revealing patterns of bat community dynamics prior to human influence are needed to separate natural and anthropogenic impacts. Here I present evidence from seven late Quaternary fossil deposits that shows continuous habitation of caves by Southern Bent-wing bats for at least the past 300,000 years. The use of particular caves as breeding or roosting sites has been consistent over this time, and mirrors precisely the patterns of cave use seen at Naracoorte today. This suggests that while the bats have been resilient to long-term change over multiple glacial cycles, the availability of appropriate cave habitat has been critical. Within-cave environmental conditions of some caves are directly influenced by surface climate. Projected climate warming systems has the potential to make these areas unsuitable. Modern habitat fragmentation and human impact on wintering caves has severely limited the capacity of this species to expand or contract its range in response to future climate change. Population monitoring and localised habitat restoration measures may not be enough to prevent extinction of this species. Palaeontological data may provide a useful tool for planning conservation efforts for this species.

Grant Information:
ARC Linkage project LP160101249

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COMPLEXITY OF EARLY PERMIAN TERRESTRIAL VERTEBRATE COMMUNITY AT RICHARDS SPUR, OKLAHOMA IS REVEALED THROUGH NEUTRON TOMOGRAPHY

REISSZ, Robert R., University of Toronto Mississauga, Mississauga, ON, Canada; BEVITT, Joseph, Australian Centre for Neutron Scattering, Lucas Heights, Australia; MACDOUGALL, Mark, Museum für Naturkunde Leibniz-Institute für Evolutions- und Biodiversitätsforschung, Berlin, Germany

The Dolese Brothers Limestone Quarry, Richards Spur, Oklahoma, preserves a highly fossiliferous early Permian infill in a series of Ordovician limestone and dolostone karst fissures. Speleothems confirm that this cave system represents a unique preservational environment for the Paleozoic, one that is distinct from the more typical Early Permian lowland deltaic/fluvial localities. The locality preserves exclusively terrestrial vertebrates, and most of the fossils have been impregnated with hydrocarbons derived from the underlying Woodford Shale. High-resolution neutron tomography has produced dark colored skeletal elements preserved in gray clays and limestones, making them easily recognizable, but the process occurred under un-aerobic conditions that facilitated the formation of abundant pyrite around and inside the bones. This unique combination makes the fossils from the cave system often difficult to image using x-ray computed tomography (x-ray CT), but ideally suited for imaging using the quasi-parallel collimated beam of neutrons, as provided by the DINGO facility at the OPAL reactor at ANSTO, Australia. The superior image quality provided by this method has revealed excellent information about the external and the internal anatomy of numerous new or little-known taxa from the locality, the richest and taxonomically most diverse assemblage of Paleozoic terrestrial vertebrates. The anatopical detail provided by neutron-CT has opened up new avenues for the study of morphological and taxonomic diversity at the locality. As a result, we have been able to recognize morphological differences among closely related taxa, significantly increasing our understanding of early Permian community structure. For example, among captorhinid eureptiles we can recognize at least three different species of Captorhinus preserved within the cave system. Similarly, among acleistorhinid parareptiles we can recognize at least three different species of Deleothyrella, and two different species of Colobomycter, and among mysteriaurine varanopid synapsids we can recognize two distinct but closely related taxa. Overall, the diversity at the locality has now exceeded 40 taxa of terrestrial vertebrates ranging in size from 150 mm to 1.5m in body length. This pattern is more in keeping with the type of taxic diversity and trophic structure usually found in modern tropical communities, rather than the relatively much lower diversity found in other coeval Paleozoic fossil localities.

RHODES, Matthew M., University of Alberta, Edmonton, AB, Canada; CURRIE, Philip J., University of Alberta, Edmonton, AB, Canada; CURRIE, Philip J., University of Alberta, Edmonton, AB, Canada

among manchongosaurids, Therizinosaurs, and other taxa in its subfamily allows a detailed assessment of homology. Comparison to the closest living relatives (crocodilians and birds) permits soft tissue reconstruction for a more comprehensive anatomical understanding.

Direct observation of the lateral pubic process of H. elizabethae shows that it has a texture and position that is inconsistent with muscle attachment. Osteological correlates of abdominal, pelvic, and caudal muscles associated with the pubis can be identified elsewhere on the specimen. However, pubogastral ligaments in crocodilians connect the gastralia and pubis in similar positions. Thus, the microraptorine lateral pubic tubercle is reinterpretated as an attachment site for pubogastral ligaments. Other well-preserved dromaeosaurid hip gasteralia linked to this region, and more plesiosauriform theropods have robust pubic boots with anterior projections inferred as anchors for pubogastral ligaments. The unique morphology in microraptorines is explained by its position proximal to the pubic apron. The lateral pubic tubercle therefore served to anchor the cuisses and accommodate locomotory musculature arising from the pubic apron. Secondly, the process forms a pulley that diverts this musculature to avoid interference with the pubogastral ligaments. Determination of the homology of the microraptorine lateral pubic tubercle allows for exploration of its functional consequences and implications for the evolution of early birds with gastralia.

Grant Information:
Strategic Priority Research Program of Chinese Academy of Sciences (Grant No. XDB26000000), National Natural Science Foundation of China (Grant No. 1688103, 41872021).

Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)
SHIFTING PATTERNS OF FUNCTIONAL INTEGRATION DURING THE EVOLUTION OF FLIGHT IN THEROPODS

RHODA, Daniel P., Indiana University, Bloomington, IN, United States of America; HELLERT, Spencer, Indiana University, Bloomington, IN, United States of America; POLLY, P. David, Indiana University, Bloomington, IN, United States of America

The transition to powered flight in theropods was one of the most significant innovations in locomotion in evolutionary history; it allowed birds to exploit new ecological niches and survive one of the worst mass extinctions in Earth’s history. This transition shifted the primary mode of locomotion from the hind limbs of non-avian theropods to the forelimbs of birds and functionally, decoupled the tail from the hind limb in birds, allowing it to be used as a rudder in flight. Previous work hypothesized that non-avian theropods had one functional module of locomotion made up of the hind limbs, hips, and tail; three modules consisting of forelimbs, hind limbs, and tail separately. We tested this hypothesis by analyzing shifts in patterns of morphological integration across the evolution of flight using matrix correlation analyses. We took 7-10 measurements of hip, forelimb, and hind limb elements of species of birds and 7 species of non-avian theropods and constructed theoretical correlation matrices to compare with observed correlation matrices. After removing the effects of size, we found that non-avian theropods and birds have different integration patterns between their forelimbs, hind limbs, and hips. This is most likely caused by differences in hind limb musculature and functional pressures; forelimb elements are much more integrated in birds than in non-avian theropods. The one-to-three functional module hypothesis was most supported, however we also found evidence that although they do not form a single functional module, the hips and forelimbs of birds are more integrated than in theropods due to the wings and rudder acting in concert during flight.

Regular Poster Session I (Wednesday, October 9, 2019, 4:15 - 6:15 PM)
HOMOLOGY OF THE MICRORAPTORINE LATERAL PUBIC TUBERCLE

RHODES, Matthew M., University of Alberta, Edmonton, AB, Canada; CURRIE, Philip J., University of Alberta, Edmonton, AB, Canada

Among dromaeosaurid theropods, Microraptorinae is distinguished by a prominent lateral pubic tubercle at midshaft of the pubis. This tubercle was tentatively identified as a muscle attachment site, but has been discussed otherwise only in the context of noting its presence or absence in paravians. Any potential anatomical or functional roles require establishment of its relationship to other pubic structures. Preservation of a lateral pubic process (hypertrophied lateral pubic tubercle) in the microraptorian Hesperornithoides elizabethae and other taxa in its subfamily allows a detailed assessment of homology. Comparison to the closest living relatives (crocodilians and birds) permits soft tissue reconstruction for a more comprehensive anatomical understanding.

October 2019 PROGRAM AND ABSTRACTS
Grant Information:
Dinosaur Research Institute, Faculty of Graduate Studies and Research (University of Alberta), Government of Alberta, NSERC

Preparators’ Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)

MANAGEMENT OF COLLECTIONS CARE PROJECTS: REFINING THE APPROACH TO CURATION WORKFLOWS AND PERSONNEL TRAINING

RHUE, Vanessa R., Natural History Museum of Los Angeles County, Los Angeles, CA, United States of America

The international community of specimen and data stewards is beset with a sheer volume and vast breadth of work to tackle at their respective institutions. Inventorying collection needs can open up the discussion of project priorities between staff (technicians, collections managers, curators, and administrators), but can also pave the way for potential funding sources that augment efforts to preserve and increase access to collections for posterity. Identifying and prioritizing specific projects is essential for optimizing use of personnel, time, space, and available resources. Quality management of collections care projects requires an understanding of the processes to be performed and their sequence of execution, documentation and refinement of established workflows, and an astute sense of how to train staff and volunteers to implement best practices accurately and efficiently. Prior to evaluating the management of collections care projects, existing staff and volunteers were assigned projects and given guidance and resources on an as needed basis, resulting in sporadic achievements of varying qualities and quantities. Upon closer critique, the sequence of decisions was flipped to first an as needed basis, resulting in sporadic achievements of varying qualities and quantities. Upon closer critique, the sequence of decisions was flipped to first prioritize feasible projects, document workflows, acquire needed resources, and then select personnel to execute the defined project within an allotted time frame. Prioritizing projects can be assessed on the basis of administrative, research, and physical needs. At the core of usable workflows are a succinct recording of the sequence of tasks to be performed, definitions of specimen and data standards, and descriptions of preventive conservation practices. Training personnel to execute workflows involves imparting a philosophy of collections care stewardship that equips them to make independent decisions in light of best practices. Exemplary workflow topics include: specimen handling, condition assessments, collections organization, taxonomic and element identification, writing locality descriptions, cataloging specimens, specimen labeling and archival housing, and digital imaging of specimens and accessory data. Useful workflows will address essential skill sets that can be adopted and amended by the user through time. Assessing and refining the management approach to collections care projects will shed light on established methods, elucidate priorities, and make strides toward standardizing the knowledge base of personnel who make decisions affecting the quality of primary and secondary scientific data held in public trust.

Regular Poster Session I (Wednesday, October 9, 2019, 4:15 - 6:15 PM)

AFFINITIES OF AUSTRALIAN TRIBOSPHENIC MESOZOIC MAMMALS

RICH, Thomas H., Museum Victoria, Melbourne, Australia; FLANNERY, Timothy, Australian Museum, Sydney, Australia; EVANS, Alistair R., Monash Univ, Monash University, Australia; WHITE, Matt, University of New England, Armidale, Australia; ZIEGLER, Timothy, Museums Victoria, Melbourne, Australia; MAGUIRE, Alanna, Melbourne, Australia; VICKERS-RICH, Patricia, Swinburne University of Science & Technology, Hawthorne, Australia

Australian tribosphenic Mesozoic mammals have previously been known only from lower dentitions. One and perhaps a second fragmentary specimen of tribosphenic upper dentitions have been found at the late Early Cretaceous Flat Rocks site in Victoria, Australia. Specimen 2009 clearly consists of two tribosphenic upper molars. It has prominent stylar cusps and an outline in occlusal view suggestive of a metatherian. A plausible occusal fit can be made with the corresponding surfaces of the ausktribosphenid Voitisha, a specimen of which is also known from the Eric the Red West site. Ausktribosphenids have been suggested to be eutherians or monotremes. No one has ever suggested affinities for them with the metatherians for quite good reasons. Should an upper molar with metatherian-like features be found conclusively to have occluded with a lower molar that is clearly not a metatherian, this would support the Australosphenida Hypothesis that the southern hemisphere hosted in the Mesozoic a group of tribosphenic mammals that were neither metatherians nor eutherians.

Specimen 2015 has been interpreted in two ways: the first as a bear-like, but strangely proportioned forelimbs had near-flat humeroulnar articulations and bore huge narrow claws – a character combination that raises fundamental questions about how palorchestids used their limbs during life and the paleoecological niche they occupied. We used newly described postcranial material from Propalorchestes sp. (Oligo-Miocene), Palorchestes parvus (Plio-Pleistocene) and Palorchestes azael (Late Pleistocene) to estimate body masses for these taxa, and virtual range-of-motion analysis to quantify their elbow mobility. This enabled empirical comparisons with a broad range of both related marsupials (including the giant diprotodontid Diprotodon) and unrelated potential functional analogues such as bears and giant sloths. Stylopodial circumferences yielded approximate body mass values of 150 kg, 360 kg and 1160 kg, respectively, for individuals of each species. Our virtual models of humeroulnar mobility found the P. azael elbow to have the lowest mobility of any taxon measured, a specialisation that may have increased stability during forelimb use in food acquisition. We found that forelimb size and mobility within the palorchestid lineage diverged markedly from that of related diprotodontid marsupials. Their robust, oddly-proportioned forelimbs had near-flat humeroulnar articulations and bore huge narrow claws – a character combination that raises fundamental questions about how palorchestids used their limbs during life and the paleoecological niche they occupied. We used newly described postcranial material from Propalorchestes sp. (Oligo-Miocene), Palorchestes parvus (Plio-Pleistocene) and Palorchestes azael (Late Pleistocene) to estimate body masses for these taxa, and virtual range-of-motion analysis to quantify their elbow mobility. This enabled empirical comparisons with a broad range of both related marsupials (including the giant diprotodontid Diprotodon) and unrelated potential functional analogues such as bears and giant sloths.

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we report two specimens from the Dunstonian Stage (early Chattian, Late Oligocene) of New Zealand that provide a potential link. Three closely related taxa, phylogenetically-ordered stemward to crownward, are Archaeospheniscus, Paraptenodytes, and Platypodytes – stem-genera near to the base of crown penguins. These penguins were medium to large in size, comparable to extant Megadytes to Aptenodytes spp. in size range. Paraptenodytes is endemic to Patagonia, with Paraptenodytes robustus and P. antarcticus from the Late Oligocene and Early Miocene, respectively. Archaeospheniscus and Platypodytes are known only from New Zealand. New Paraptenodytes-like specimens (OU 21980 and OU 22661) from Hakataraumu Valley, New Zealand are from the Kokoamu Greensand (Duntroonian), and coeval with Archaeospheniscus and the earliest Platypodytes. OU 21980 has a partial coccyx and proximal humerus. OU 22661 is more complete, similar in size to modern Aptenodytes patagonicus, with various axial, pectoral girdle, wing and leg elements preserved, but not the tarsometatarsus. These new specimens differ from Archaeospheniscus and Platypodytes in humeral features that are shared with Paraptenodytes: a more inflated, caudally-skewed articular surface apex on the humeral head. Overall, the taxonomically-informative humerus shows a close phenetic similarity, and shares key diagnostic features, with Paraptenodytes – though the humeral shaft of OU 22661 is more sigmoidal. This shaft curvature suggests the New Zealand specimens are positioned stemward to Paraptenodytes. Penguins of Megadytes size and larger, except for the robust Platypodytes, disappear from the New Zealand fossil record by the Waiaitian Stage (latest Oligocene). The new specimens increase the Kokoamu Greensand penguin assemblage to >8 species.

Grant Information:
National Geographic Society Research Fund (grant number 3542-87)

Regular Poster Session I (Wednesday, October 9, 2019, 4:15 - 6:15 PM)

NEW CRESTED PTEROSAUR MATERIAL FROM THE LOWER CRETACEOUS (ALBIAN) TOOLEBUC FORMATION OF QUEENSLAND, AUSTRALIA, AND THE EVOLUTION OF AUSTRALIAN PTEROSAURS

RICHARDS, Timothy M., The University of Queensland, Brisbane, Australia; STUMBATI, Paul E., Sturtz Studios, Killarney, Australia; SALISBURY, Steven W., The University of Queensland, Brisbane, Australia

Pterosaur fossils from Australia are exceptionally rare, comprised entirely of isolated and often fragmentary bones. Since the discovery of the continent’s first pterosaur fossils some forty years ago, only fifteen specimens have been described. Moreover, of all the specimens described so far, only two are sufficiently informative to be recognised as new species. To date, the Lower Cretaceous (middle Albian) Toolubuc Formation of central-western Queensland is the most productive horizon for Australian pterosaurs. Here we report on the discovery of new pterosaur material from the Toolubuc Formation near Richmond, north-west Queensland. The material includes a partial skull and two partial, crest mandibles, both of which present features that indicate affinities with Ornithocheiridae. These include characteristics of the maxillary and mandibular rostrum and associated crests, and the size, spacing and orientation of alveoli. The presence of ornithocheirid or ‘ornitho-choirid’ pterosaurs has previously been reported from the Lower Cretaceous of Australia and is consistent with their reported cosmopolitan distribution during this period. However, the deep crests and overall blade-like nature of the mandible appear to be unique among ornithocheirids, and may warrant the erection of new genera. In contrast to other Mesozoic vertebrates from Australia, phylogenetic analysis reveals that there is no evidence of an endemic Australian radiation within Ornithocheiridae. Instead, Australian ornithocheirids show affinities to ornithocheirids from South America. Unfortunately, stable isotope studies on amphibians are currently under extreme pressure, with global climate change, leading to habitat change, and emerging diseases, among others, contributing to declines in diversity worldwide. To better understand the response of amphibians to these complex issues, there is a need for more research investigating the influence of climate change on amphibian communities. The fossil record can provide a more detailed historical context to better understand how species respond to current and future environmental change. Stable isotope analysis, in particular, can be used to understand the habitat use, diet, and life-history of extinct animals. Unfortunately, stable isotope studies on amphibians are rarely performed and fossil taxa, especially amanarans. The fossil locality, Piseo, located in northeastern Germany provides a unique opportunity to study past amphibian communities, with 85,000+ anuran specimens recovered and housed at the Museum für Naturkunde, Berlin. Although there currently are no absolute dates for the site, it is thought that it spans the Pleistocene-Holocene transition and may even represent the Last Glacial Maximum. Here we report δ13C, δ15N and δ18O values of bone collagen from Psidea Rana temporaria, Rana arvalis, and Bufo bufo specimens. Preliminary results indicate excellent collagen preservation (CN ratio: 3.17-3.32). The δ18O values differed significantly among the three species (ANOVA, p < 0.001). A post-hoc Tukey test indicated that mean δ18O value of B. bufo (9.9‰) differs from R. temporaria (5.7‰) and R. arvalis (6.3‰), but R. temporaria and R. arvalis are not significantly different from each other. B. bufo exhibited the largest range in δ18O values (7.3 – 12.4%), which is representative of the varying trophic levels that B. bufo occupies. Neither mean δ13C or mean δ15N values are significantly different among the three species (ANOVA, p > 0.05). B. bufo exhibited the largest range in δ15N values (8.5 – 10.7%), which may be representative of the species’ use of both terrestrial and aquatic habitats. Interestingly, B. bufo had the lowest range in δ13C values (21.42 – 20.09‰), while R. temporaria had the largest (22.17 -19.08‰).

Continuing work will expand the number of Psidea anuran specimens analyzed, the analysis of co-occurring taxa, and radiocarbon dates for the site. In addition, the analysis of specific species will inform on the potential for the use of fossil frogs as isotopic proxies of paleopreclination.

Grant Information:
Paleontological Society Stephen Jay Gould Student Award

Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM)

DESCRIBING ENAMEL IN SQUAMATES: UTILIZING NON-DESTRUCTIVE CT SCANS TO CHARACTERIZE ENAMEL IN EXTANT AND EXTINCT LIZARD SPECIES


Lizards represent a geographically and temporally diverse group of animals, occupying almost every biogeographic zone since the Mesozoic (e.g., > 210 million years). Their potential to answer ecological questions (i.e., response to climate change) via geochemical proxies (i.e., δ13C, δ18O) has largely been unexplored, but improved technologies are making this challenge achievable. Most geochemical analyses of fossil materials utilize mammalian material, a dense, macrofossil that resists diagenesis, and is plentiful enough to be analyzed geochemically. It has yet been shown that these enamel characteristics (i.e., density, thickness, abundance) exist within squamate taxa. Utilizing high resolution X-ray tomography scans of lizard enamel, we quantified squamate enamel thickness, density, location within the tooth, and volume using the segmenting software VGSTUDIO MAX 3.2. Three extant lizard taxa were selected as a base of comparison; Tupinambis teguixin (tegu) was selected for its placodont/heterodont dentition, Cercosaurus bifidus (chameleon) was selected for its acrodont dentition, and Dracaena guianensis was selected for its molariform dentition. Three extant taxa (Proxestops sp., Amphibeaenia, Saniwa sp.) collected from Bighorn Basin, Wyoming deposits, all in close temporal association with the Paleocene-Eocene Thermal Maximum (PETM), were selected to determine if usable quantities of fossil enamel for geochemical analyses existed. All scans were compared to a mammal species (Tadarida brasiliensis) to determine that the density of lizard enamel is comparable to mammalian enamel. The extant scans illustrated distinct differences in enamel characteristics between dentition type. The tegu had a dense enamel tip, with softer material closer to the root. In addition, replacement teeth were substantially denser than in-place teeth. The chameleon had the least dense enamel, but had a dense, enamel-like material running along from the tip of the tooth against the labial surface to the ventral portion of the dentary. Dracena had more mammalian like enamel, with a thick (~100 μm) outer layer wrapping the entire tooth exterior. All lizards were within 8% the density of the mammalian comparison. The fossils, all isolated mandibular teeth, show Dracena like enamal.
DIVERGENT MAMMALIAN BODY SIZE IN A STABLE EOCENE GREENHOUSE CLIMATE

RING, Simon, University of Tübingen, Tübingen, Germany; BOCHERENS, Herve, University Tübingen, Tübingen, Germany; WINGS, Oliver, Martin-Luther-University Halle-Wittenberg, Halle (Saale), Germany; RABI, Marton, Martin-Luther-University Halle-Wittenberg, Halle (Saale), Germany

The response of mammals to climate change during the Cenozoic is of major interest to paleobiology and conservation. A relationship between body mass and climate has been repeatedly inferred for abrupt global warming events during the Eocene and substantial global-scale Cenozoic cooling was accompanied by a progressive increase in the size of mammals. However, testing the robustness of this relationship has been hindered by the paucity of suitable fossil material covering large temporal ranges. Here we analyze the fossil record of two dominant herbivores, propalaeotheriid horses and tapiromorphs, which differ significantly in their body size trajectories despite a consistently humid, subtropical climate. While measured bioapatite samples exhibit δ¹³C and δ¹⁸O is isotopic signatures characteristic of a tropical evergreen forest, body mass of horses and tapiromorphs diverges rapidly across the same time interval, from an initial mean body size gap of 110 kg to 220 kg at the end of the record. We attribute this divergent body size evolution to a disparity in life history. The fast-slow life history concept predicts that small-sized early horses had high metabolic/reproductive advantages. Our results therefore provide likely resulted in an opposing body-size response to selective pressures by herbivores of the European Eocene, lived and reproduced more “slowly” due to the smaller mean body size gap at the end of the record. We show that the two dominant herbivores, propalaeotheriid horses and tapiromorphs, differ significantly in their body size trajectories despite a consistently humid, subtropical climate. While measured bioapatite samples exhibit δ¹³C and δ¹⁸O isotopic signatures characteristic of a tropical evergreen forest, body mass of horses and tapiromorphs diverges rapidly across the same time interval, from an initial mean body size gap of 110 kg to 220 kg at the end of the record. We attribute this divergent body size evolution to a disparity in life history. The fast-slow life history concept predicts that small-sized early horses had high reproductive / biomass-production rates whereas tapiromorphs, the largest herbivores of the European Eocene, lived and reproduced more “slowly” due to the lack of comparably-sized predators. These discrepant life histories likely resulted in an opposing body-size response to selective pressures by maximizing metabolic/reproductive advantages. Our results therefore provide unique insight into the relationships of body size and lifestyle in extinct mammal faunas and suggest that modern ecosystem structuring did not evolve before the Eocene. This is also consistent with the view that intrinsic biotic processes dominate over climate forcings in driving animal ecomorphology outside abrupt climate events. Finally, our work also has implications for regional biochronology and the formation of the Geiseltal fossil site.

Grant Information: Volkswagen Foundation “Research in Museums” grant (90 978) to MR.

Colbert Prize Poster Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)  
A REASSESSMENT OF THE PHYLOGENETIC CHARACTERISTICS OF CROCODYLIA USING A SUPER-MATRIX APPROACH

RIO, Jonathan P., Imperial College London, London, United Kingdom; MANNION, Philip D., London, United Kingdom; SUTTON, Mark, Imperial College London, London, United Kingdom

The crown-group Crocodylia is a speciose and globally distributed clade, composed of 26 extant and approximately 150 extinct species extending back to the Late Cretaceous. Despite a substantial increase in the number of fossil crocodylian species described in recent decades, there has not been a proportional increase in character sampling, and few studies have included more than 80 in-group taxa. This hinders resolution in large parts of the crocodilian tree and the testing of phylogenetic hypotheses. In particular, the relationships of Gavialis gangeticus and Tomistoma schlegeli has been a persistent problem, with topological differences between morphological and molecular datasets resulting in a 40 million year discrepancy in the proposed origin of the gavialid lineage. We have assembled the largest and most comprehensive dataset to date for Crocodylia, which comprises 363 morphological characters scored for 146 species (23 extant and 123 extinct taxa). This dataset represents a global sampling of crocodylian taxa, 85% of which were scored based on direct examination of specimens. All existing characters were critically reviewed from personal observations and an extensive literature review, resulting in extensive modifications to most characters, and the identification of 48 new characters. We identify new anatomical similarities in the orbito-temporal canals of the basal gavialid taxa Thoracosaurus and Eosuchus, which differ from the condition observed in other gavialoids (Eosuchus, Gavialis, Crocodylus, Tomistoma, and Gavialis). The latter share a condition with Crocodylidae (i.e., crocodylomorphs and tomoctenomorphs), in which a large fossa extends across the posterior wall of the supratemporal fenestra from the medial edge of the orbito-temporal canal. This, and other revised novel characters, appear to support the view that “thoracosaurus” might not be closely related to Gavialis, an important first step in closing the temporal gap between morphological and molecular analyses. Our dataset includes 35 continuous characters, derived by quantifying discretely coded characters in existing datasets. We find that the majority (30) of these are normally distributed, showing a continuous spectrum of values. This supports their treatment in phylogenetic analyses, and raises the question of whether the character states for other discretely coded characters are arbitrarily drawn.

Grant Information: This research was supported by a NERC DTP scholarship.

A NEW ZIPHODONT EUSUCHIAN FROM THE PLEISTOCENE OF QUEENSLAND, AND IMPLICATIONS FOR AUSTRALASIA’S ZIPHODONT CROCODYLIAN DIVERSITY

RISTEVSKI, Jorgo, The University of Queensland, Brisbane, Australia; PRICE, Gilbert J., The University of Queensland, Brisbane, Australia; CRAMBL, Jonathan, The University of Queensland, Brisbane, Australia; SOBBE, Ian H., The University of Queensland, Brisbane, Australia; MOLNAR, Ralph E., University of California Museum of Paleontology, Berkeley, CA, United States of America; LOUYS, Julien, Griffith University, Brisbane, Australia; WILSON, Peter, The University of Queensland, Brisbane, Australia; NGUYEN, Ai D., The University of Queensland, Brisbane, Australia; ZHAO, Jian-xin, The University of Queensland, Brisbane, Australia; FENG, Yue-Xing, The University of Queensland, Brisbane, Australia; BEIRNE, Lawrence, The University of Queensland, Brisbane, Australia

Ziphodonty, or dentition containing labiobuccally compressed and serrated teeth, is a condition that has evolved multiple times within Crocodylomorpha, and with ziphodont crocodylomorph remains known globally from Mesozoic and Cenozoic sediments. During the Cenozoic, most currently recognized ziphodont crocodylomorphs disappeared by the end of the Miocene, except in Australia, where some eusuchian ziphodonts survived well into the Pleistocene. For almost 40 years, virtually all ziphodont crocodyliform material from the Australian Cenozoic has been referred to Quinkana, a genus of small to medium-sized crocodylians. However, a recently discovered specimen from Queensland represents a new genus and species that significantly alters our understanding of Australasian ziphodont crocodylian diversity and evolution. This new taxon, represented by a mostly complete skull, a left mandible, and a partial osteoderm is from a large-bodied (~3.5 m long) individual. It displays a unique combination of features, such as a relatively broad and moderately tall rostrum with complete overbite dentoition; tall maxillary alveolar processes; distinct but non-functional notches at the lateral premaxillary-maxillary sutures; laterally positioned orbits; an intermaxillary bar; a pair of concavities located posteriorly on the maxilla; squamosal ‘horns’; a distinctive ‘B’ shaped secondary chomand; and, a posteroventrally facing basisphenoid plate. Ziphodonty is demonstrated by the presence of a maxillary tooth that bears true denticiles on its canine. Several of the above-mentioned characters are consistent with trophic adaptations suggesting it was a terrestrial predator. The phylogenetic position of the new taxon was assessed using an extensive dataset that contains most hitherto known Australasian extinct crocodylians. Results of the analysis show that the new taxon is nestled within the Moschocnidae, and was recovered as a sister taxon to Quinkana. Dating of the specimen demonstrates that it lived ~120 ka, making it the youngest dated ziphodont crocodylian globally. The type species of Quinkana, Q. forsterstrum, is also from the Pleistocene, and along with other crocodylians such as the new discovered taxon, Crocodylus, Pallimnarchus, large varanids, and madasgic snakes illustrate a carnivorous fauna dominated by reptiles, seemingly in contrast with other continents where mammalian carnivores occupied the apex predator roles during the Quaternary.

Grant Information: Australian Research Council grants DP120101752 and DE120101533.

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Grant Information: Australian Research Council grants DP120101752 and DE120101533.

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Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM)

INTRAFORMATIONAL STRATIGRAPHIC CORRELATION OF VERTEBRATE LOCALITIES WITHIN THE UPPER CRETACEOUS KAIPAROWITS FORMATION TIED TO HIGH-PRECISION U-PB CA-ID-TIMS ZIRCON DATING OF 11 BENTONITE MARKER HORIZONS: IMPLICATIONS FOR EVOLUTIONARY AND ECOLOGICAL PATTERNS

ROBERTS, Eric M., James Cook University, Townsville, Australia; BEVERIDGE, Tegan, James Cook University, Townsville, Australia; RAMEZANI, Jahan, MIT, Boston, MA, United States of America; TITUS, Alan, BLM, Kanab, UT, United States of America

The Upper Cretaceous Kaiparowits Formation in southern Utah has produced a remarkable number of new macrovertebrate fossil localities over the last 18 years, which has resulted in the description of >20 new dinosaur species and recognition of an unusually rich diversity and abundance of crocodiles and turtles. Moreover, the formation represents one of the best-sampled portions of other well-sampled mid-late Campanian continental vertebrate faunas of Laramidia preserved across the Western Interior Basin. However, the Kaiparowits Formation is exposed across a vast, ~70 km N-S transect of difficult to access wilderness with large roadless sections, making intraformational stratigraphic correlations between widely spaced fossil localities difficult. Over the last three years, our team has identified as many as 13 bentonite horizons through the 870+ meter thick succession that provide key marker horizons for correlation. We have systematically dated (or redated in many cases) 11 of these bentonites using high-precision U-Pb zircon geochronology (via chemical abrasion isotope dilution thermal ionisation mass spectrometry [CA ID TIMS]). Dating was focused in two primary stratotype sections, one in the north and one in the south, to act as tie points for systematically correlating dozens of legacy and recent vertebrate fossil stratotype sections, one in the north and one in the south, to act as tie points for systematically correlating dozens of legacy and recent vertebrate fossil localities. The new dating has significantly reduced uncertainties associate with the earlier dating. Here we present these new ages and a better-resolved internal stratigraphic framework, allowing us to more precisely and accurately estimate the temporal ranges of taxa from the Kaiparowits Formation. This work has significant implications for understanding the evolutionary and ecological history of this important fauna.

Grant Information:
National Science Foundation-EAR-1424892

Technical Session IX (Thursday, October 10, 2019, 3:30 PM)

ELUCIDATING CRYPTIC AXIAL SKELETAL REGIONALIZATION IN REPTILIA: IMPLICATIONS FOR VERTEBRATE EVOLUTIONARY-DEVELOPMENTAL HISTORY

ROBERTS, Lucy E., University of Cambridge, Cambridge, England; HEAD, Jason J., University of Cambridge, Cambridge, United Kingdom

Reptiles exhibit extreme plasticity in axial skeleton morphology, however, regionalization has been considered conservative across the clade, in the tradition of long held perceptions. The advent of mostly non-destructive imaging techniques such as computed tomography (CT) has alleviated some of these difficulties and allowed for the reconstruction and visualization of a variety of anatomical structures. Two such structures of interest are the cochlea and semi-circular canals, located in the bony labyrinth of the inner ear. Previous research has concluded that the size and shape of the cochlea and the size and orientation of the semicircular canals are correlated with hearing capabilities and locomotion, respectively. To date, the bony labyrinth of only one reptile—C. pattersoni—has been reconstructed. Here, we present the first description of the bony labyrinth of Caenolambda pattersoni, a relatively unspecialized and likely terrestrial reptile from the Late Cenozoic of North America. Based on our scans of the holotype skull, the bony labyrinth of C. pattersoni is small relative to the size of the skull. Partial reconstructions of both cochlea reveal that each has approximately 1.5 turns (equating to ~540°), suggesting that C. pattersoni had a limited acoustic range and was unlikely to have been able to detect low frequency sound. The reconstructed left anterior and posterior semicircular canals are positioned at 90° to each other, suggesting that C. pattersoni may have been an unspecialized terrestrial locomotor, although the lateral semicircular canals must be reconstructed before more robust inferences can be made. Our research is ongoing and we will eventually include segmentation and reconstruction of more of the cochlea and semicircular canals, including the lateral semicircular canals.

Grant Information:
NERC ESS Studentship to LER

Technical Session XI (Friday, October 11, 2019, 9:45 AM)

QUATERNARY EXTINCTIONS AND NON-EXTINCTIONS ON THE ISLAND OF SRI LANKA AND THEIR RELATIONSHIP TO LATE PLEISTOCENE HOMO SAPIENS

ROBERTS, Patrick, Max Planck Institute for the Science of Human History, Jena, Germany; WEDAGE, Oshan, Max Planck Institute for the Science of Human History, Jena, Germany; AMANO, Noel, Max Planck Institute for the Science of Human History, Jena, Germany

Sri Lanka, and indeed South Asia more broadly, has been relatively neglected in the context of the Middle and Late Pleistocene extinction of Quaternary vertebrates. This is despite the fact that it has yielded some of the earliest global evidence for the specialized exploitation of tropical landscapes by our species, has been variously isolated as a consequence of changing sea-level, and sits at the centre of climatic influences of the Indian Ocean Monsoon system. Here, we report evidence for the extinction and persistence of different mammalian taxa during the Quaternary in Sri Lanka, focusing on cave and rockshelter archaeological sites in the Wet Zone rainforests of the island. While the former case studies suggest the long-term, sustainable exploitation of small, and some large, mammalian taxa by growing populations of Homo sapiensinforagers, the latter implies that a number of large mammals disappeared prior to the Last Glacial Maximum. We argue that with further dating work, excavation, and multidisciplinary methodologies, Sri Lanka could act as the ideal Asian-Pacific ‘laboratory’ setting for discerning the relative significance of island isolation, human hunting, and climatically-induced environmental change on diverse vertebrate taxa with difference niches and vulnerabilities.

Grant Information:
We would like to thank the Max Planck Society, National Geographic, and the University of Jayawardenepura, Sri Lanka for funding.

Regular Poster Session I (Wednesday, October 9, 2019, 4:15 - 6:15 PM)

BONY LABYRINTH MORPHOLOGY OF THE PANTODONT CAENOLAMDBA PATTSONERI

ROBSON, Selina V., University of Calgary, Calgary, AB, Canada; SCOTT, Craig, Royal Tyrrell Museum of Paleontology, Drumheller, AB, Canada; THEODOR, Jessica M., University of Calgary, Calgary, AB, Canada

Pantodons are a clade of early Cenozoic herbivores that are some of the earliest mammals to have achieved a large body size. Pantodons exhibit significant cranial and postcranial morphological diversity, with some species likely having been terrestrial, semi-aquatic, or even arboreal. Despite this diversity, the sensory capabilities and locomotor habits of pantodons remain poorly understood, in large part because of the inaccessibility of some of the relevant fossil deposits, the potential loss of fossil breakdown due to the warm climate, and the lack of high-precision U-Pb zircon geochronology. The advent of mostly non-destructive imaging techniques such as computed tomography (CT) has alleviated some of these difficulties and allowed for the reconstruction and visualization of a variety of anatomical structures. Two such structures of interest are the cochlea and semi-circular canals, located in the bony labyrinth of the inner ear. Previous research has concluded that the size and shape of the cochlea and the size and orientation of the semicircular canals are correlated with hearing capabilities and locomotion, respectively. To date, the bony labyrinth of only one pantodon—C. pattersoni—has been reconstructed. Here, we present the first description of the bony labyrinth of Caenolambda pattersoni, a relatively unspecialized and likely terrestrial pantodon from the Late Cenozoic of North America. Based on our scans of the holotype skull, the bony labyrinth of C. pattersoni is small relative to the size of the skull. Partial reconstructions of both cochlea reveal that each has approximately 1.5 turns (equating to ~540°), suggesting that C. pattersoni had a limited acoustic range and was unlikely to have been able to detect low frequency sound. The reconstructed left anterior and posterior semicircular canals are positioned at 90° to each other, suggesting that C. pattersoni may have been an unspecialized terrestrial locomotor, although the lateral semicircular canals must be reconstructed before more robust inferences can be made. Our research is ongoing and we will eventually include segmentation and reconstruction of more of the cochlea and semicircular canals, including the lateral semicircular canals.
Grant Information:
Royal Tyrrell Museum Cooperating Society Student Research Program
Education and Outreach Poster Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)

PALEONTOLOGY EDUCATION THROUGH PALEOART: A TWO-YEAR EXPERIENCE IN A BRAZILIAN HIGH SCHOOL

RODRIGUES, Taissa, University Fed. Espirito Santo, Vitoria, Brazil

Brazil is home to a wealth of fossils, and Federal directives recommend (TO n. 374/2016). Projects give preference for smaller groups (6 to 7), composed by students of inclusiveness. Even with the scholarship, they could not afford to attend meetings when they were able to attend the meetings at once. One student reported that, as positive outcomes, eleven models were produced. Initial difficulties on scaling animals were discussed and improved in later models. Anatomical accuracy varied depending on individual abilities but the overall result exceeded expectations. Interestingly, students used mostly bright colors for marine vertebrates (fishes, reptiles) but not for terrestrial ones (reptiles, mammals).

The main difficulty was maintaining a cohesive group. In total, 21 students participated, as some opted out or concluded high school and had to be replaced. Although expected, such changes were challenging because the group’s familiarity on the topic was not homogeneous. Also, seldom all students were able to attend the meetings at once. One student reported that, even with the scholarship, they could not afford to attend meetings when they were held at the university. Therefore, we recommend that future, similar projects give preference for smaller groups (6 to 7), composed by students of the same grade, and, as often as possible, include scholarships aiming inclusiveness.

Grant Information: This project was funded by a joint FAPES/CNPq/Serra municipality grant (TO n. 374/2016).

Technical Session VIII (Thursday, October 10, 2019, 4:00 PM)

NEW FOSSILS FROM ASIA WIDEN EARLY ANTLER DIVERSITY AND YIELDED OLDEST ANTLERS KNOWN

ROESSNER, Gertrud E., Bayerische Staatsammlung Fuer Palaeontologie Und Geologie, Munich, Germany; WANG, Xiaoming, Natural History Museum of Los Angeles County, Los Angeles, CA, United States of America; WANG, Shi-Qi, Institute of Vertebrate Paleontology and Palaeoanthropology, Beijing, China

Antlers are unique organs with a very complex physiology including periodic regeneration and they are the autopomorphies of deer (Cervidae, Artiodactyla). The fossil record of antlers is crucial for the understanding of evolution and phylogeny of these animals. Especially exciting are the earliest records from environment of a given time period. After that, they constructed scale models of these biotas. Materials used to build the models included a wooden base (about 32 x 32 cm), paint, and colored cold porcelain, which is cheap, easy to shape, and harderens upon contact with air resulting in a permanent form. Students also used sticks for support, and transparent resin, papier-mâché, and sand for texture. As positive overall, eleven models were produced. Initial difficulties on scaling animals were discussed and improved in later models. Anatomical accuracy varied depending on individual abilities but the overall result exceeded expectations. Interestingly, students used mostly bright colors for marine vertebrates (fishes, reptiles) but not for terrestrial ones (reptiles, mammals).

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Technical Session VIII (Thursday, October 10, 2019, 4:00 PM)

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Grant Information: This project was funded by a joint FAPES/CNPq/Serra municipality grant (TO n. 374/2016).

Technical Session VIII (Thursday, October 10, 2019, 4:00 PM)
We propose a synthetic and overarching framework that aims to reconstruct paleoecolour more accurately and consistently by accounting for as many contributing factors as possible: types of integumentary structures, chemical signatures of pigments, melanosome morphology and arrangement, melanin concentration, macroscopic colour patterns, and taphonomic pathways of pigments.

Grant Information:
This project was funded by Hong Kong PhD Fellowship (HKPF PF16-09281).

Technical Session VII (Thursday, October 10, 2019, 9:00 AM)

A NEW ALLIGATORINE FROM THE MIDDLE EOCENE OF UTAH AND THE ORIGINS OF MODERN ALLIGATOR

RUBIN, Margaret, University of Iowa, Iowa City, IA, United States of America

Extant Alligator comprises two species – the American (A. mississippiensis) and Chinese (A. sinensis) alligators – but it is a fossil record well over 20 bones/m². Well-preserved cranial elements confirm pigments.

WYENBERG-HENZLER, Taia C., Carleton University, Ottawa, ON, Canada

Regular Poster Session III (Friday, October 11, 2019, 4:15 - 6:15 PM)

NEW CONTRIBUTIONS TO THE CERATOPSID RECORD OF THE DINOSAUR PARK FORMATION FROM RECENT FIELDWORK ALONG THE SOUTH SASKATCHEWAN RIVER, ALBERTA, CANADA

RUFOLLO, Scott J., Canadian Museum of Nature, Ottawa, ON, Canada; MALLON, Jordan, Canadian Museum of Nature, Ottawa, ON, Canada; CURREY, Margaret, Canadian Museum of Nature, Ottawa, ON, Canada; DUDGEON, Thomas W., Carleton University, Ottawa, ON, Canada; CURRY, MELANIE of Nature, Ottawa, ON, Canada; SWAN, Susan, Canadian Museum of Nature, Ottawa, ON, Canada; WYENBERG-HENZLER, Taia C., Carleton University, Ottawa, ON, Canada

The Dinosaur Park Formation (DPF) of southern Alberta, Canada – well-known for the many dinosaur specimens discovered in the intensively researched exposures within Dinosaur Provincial Park along the Red Deer River – provides an invaluable window into the Late Cretaceous world (~75.5 Ma, CAMPANIAN AGE). Other regions of the province, however, also harbour significant outcrops of this important deposit. Ongoing fieldwork initiated by the Canadian Museum of Nature (CMN) in 2013 focuses on the valley of the South Saskatchewan River around 80 km to the southeast, near the hamlet of Hilda, bringing to light new material concerning the dinosaur fauna that inhabited the proximate coastal terrain forming the western edge of the Western Interior Seaway.

Presented here are the results of initial work concerning two 2015 finds related to the horned-dinosaur family Ceratopsidae. The first is a newly identified occurrence of the Hilda mega-bonebed, a feature consisting of over a dozen feature previously unnoted for other component bonebeds of the broader Hilda-area assemblage.

The second discovery detailed here, an isolated Chasmosaurus skull uncovered in stratigraphically older deposits near the bonebed, is significant for the fact that it represents a rare long-horned variety considered to be a distinct species by some authors (C. canadensis). The taxonomy of Chasmosaurus is problematic, only two species generally regarded as being valid (C. russelli and C. belli). The status of the long-horned morph is uncertain, a recent review assigning the few known specimens to Chasmosaurus sp. due to a lack of diagnostic features and unknown stratigraphic position for previously described specimens. The CMN skull occurs within the lower DPF and serves to anchor a more detailed examination of the status of C. canadensis as a valid taxon.

Technical Session I (Wednesday, October 9, 2019, 11:45 AM)

THE EVOLUTION OF SEALS (FAMILY PHOCIDAE) IN THE SOUTHERN OCEAN: NEW FOSSIL EVIDENCE FROM NEW ZEALAND

RULE, James P., Monash University, Melbourne, Australia; ADAMS, Justin W., Monash University, Melbourne, Australia; EVANS, Alistair R., Monash University, Melbourne, Australia; TENNYSON, Alan J., Museum of New Zealand Te Papa Tongarewa, Wellington, New Zealand; SCOFIELD, Paul R., Canterbury Museum, Christchurch, New Zealand; FITZGERALD, Erich M., Museums Victoria, Melbourne, Australia

The origin of southern true seals (Subfamily Monachinae) is one of the greatest unsolved mysteries of pinniped palaeontology, in part due to a poor fossil record. Current biogeographic hypotheses identify the North Atlantic as the centre of dispersal of Phocidae (true seals), including monachines. However, data from the fossil record of Australia and New Zealand has so far been missing from such analyses, which represents a critical gap on the margin of the Southern Ocean.

We present new fossil Phocidae from the Pliocene of Taranaki, New Zealand (3.4-3.0 Ma). Consisting of multiple specimens, including complete crania, the sample provides evidence of a single species of small sized (~2 m total length) monachine seal. This taxon possesses broad postcanine dentition and specialised ear morphology. Morphological data (148 characters) was collected from all extant and 16 fossil phocids, and 5 outgroup taxa. Molecular data (16 nuclear genes, 12 molecular genes) were downloaded from Genbank for all extant phocids, Odobenus, and Arctocephalus. Parsimony and Bayesian (combined evidence) analyses demonstrate a monophyletic Phocinae and Monachinae, supporting recent work. The Taranaki phocids, along with fossil phocids from Beaumaris (Miocene-Pliocene of Australia), were found to be early diverging monachines.

This demonstrates that there was a greater diversity of Monachinae on the fringes of the Southern Ocean during the Neogene. Further, a biogeographic analysis suggests that the Southern Ocean played a larger role in monachine evolution than previously thought, with several groups of monachines originating in the Southern Ocean. Interestingly, only small-sized phocids appear in the pre-Pliocene fossil record of the Southern Ocean, contrasting with the larger phocids that exist there today. This highlights the importance of southern higher latitude environments to the evolution of true seals.

Grant Information:
This research was supported by an Australian Government Research Training Program Scholarship and a Robert Blackwood Partnership PhD Top-Up Scholarship (JPR).

Regular Poster Session III (Friday, October 11, 2019, 4:15 - 6:15 PM)

A NEW NEOSUCHIAN CROCODYLMORPH (REPTILIA, MESOEUCROCODYLIA) FROM THE MIDDLE CRETACEOUS LONGING FORMATION, YANJI BASIN, NORTH-EASTERN CHINA

RUMMEL, Paul, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, China; XU, Xing, Institute of Vertebrate Paleontology & Paleoanthropology, Beijing, China; WU, Xiaochun, Canadian Museum of Nature, Ottawa, ON, Canada; JIN, Feng, Yanji Paleontology Research and Protection Center, Yanji, China; WEN, Dexiu, Yanji Paleontology Research and Protection Center, Yanji, China; WANG, Bing, Yanji Paleontology Research and Protection Center, Yanji, China

Numerous dinosaurian, crocodyliform, and testudine fossils have recently been recovered from the Longjing Formation in Yanji Basin, adding new significance to the temporal and spatial distribution of the mid-Cretaceous dinosaur fauna in Northern China. Among them are fossil remains (IVPP-YJD 00009) representing a new genus and species of crocodyliform. The
A new ankylosaur dinosaur skeleton from the Upper Jurassic of Portugal

**RUSSO, João, FCT-NOVA, Lourinhã, Portugal; MATEUS, Octávio, FCT-NOVA, Lourinhã, Portugal**

Ankylosaurs are very rare in Upper Jurassic and their record is restricted to five genera. Among them, is the poorly known *incertae sedis Dracopelta zbyszewskii* from the Upper Triasian of Portugal. Here we present a new specimen recovered in the coastal cliffs near the beach of Porto da Calada, about 40 km North of Lisbon, in a light gray, fine to medium grained sandstone, close to the top of the Lourinhã formation, Upper Triasian. It consists of a nearly complete skull, with maxillary teeth, at least eleven articulated dorsal vertebral with proximal half of ribs, ten articulated anterior caudals, mostly complete and articulated sacrum, several fragments of disarticulated and broken ribs, both femora articulated in the acetabulum, partial ilia with attached pelvic shield, right humerus missing the proximal end, partial right scapulocoracoid, over 180 osteoderms (lateral, caudal and dorsal, most in situ) of various size (0.5-18 cm), at least 40 ossified tendons mostly attached to the vertebral, and partial pelvic shield. This specimen (FCT-UNL 702), still under preparation, is one of the most complete Jurassic ankylosaurs. Many of the ankylosaurian traits are present: mediolateral-inset maxillary tooth row; dorsal expanded proximal T-shaped ribs; posteriormost dorsal vertebrae fused to form a rod; horizontal hypotrophied preacetabular process, showing attachment scar of a posterior dorsal rib; robust humerus with deltopectoral crest extending mid shaft; distally positioned ridge-shaped fourth trochanter; extensive dorsal armor plates, lateral plates and pelvic shield; and large hollow-based lateral plates. The femoral head is separated from greater trochanter by a distinct slope which is diagnostic of Nodosauridae, but contrary to these, the posterior width of the skull is twice the width across the orbits. The phylogenetic position of the Portuguese specimen is not yet fully understood, but likely close to the split between the two major clades: Nodosauridae and Ankylosauridae. Also, it is still unclear if this is a second specimen of the sympatric and coeval *D. zbyszewskii*

**Grant Information:**

This research was supported by Fundação para a Ciência e Tecnologia (grant SFRH/BD/128717/2017).

**Funding Meaningful Research Experiences encourages Undergraduates to Pursue Degrees in Paleontology and Geoscience**

**RUTZKY, Sara M., Wake Technical Community College, Raleigh, NC, United States of America**

Minority students are highly underrepresented in the geosciences, especially in vertebrate paleontology. Additionally, the number of new students entering a geology or paleontology major in the United States is not keeping up with industry demand. In order to address these issues, Wake Technical Community College (WTCC) geology faculty partnered with faculty at North Carolina State University (NCSU) from 2012-2019 and with researchers at the North Carolina Museum of Natural Sciences (NCMNS) from 2016-2019 to provide paid summer research internships to community college geology students who have completed one or two geology courses. Student interns perform meaningful research, including planning, data collection, and analysis under the mentorship of faculty, researchers, and graduate students at their partner institutions, and culminate the experience in a paper or poster that is presented at both local and national/international meetings, including both the Geological Society of America (GSA) and the Society of Vertebrate Paleontology (SVP). Successful student interns come from diverse backgrounds including a majority of minority populations. The experience for many interns has been transformative and has led to them continuing their education in a geoscience field. We find that meaningful paid research experiences early in a student’s career can encourage minority and underrepresented student groups to choose a major and career in geoscience or paleontology.

**Grant Information:**

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**Technical Session XII (Friday, October 11, 2019, 9:45 AM)**

**Sexual Dimorphism in Non-Avian Dinosaurs and Other Extinct Taxa: The Importance of Effect Size Statistics in Paleontology**

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Despite many published reports of sexual dimorphism in extinct taxa, such claims in non-avian dinosaurs have been significantly underrepresented in recent years and have often been met with sharp criticism. Given that dimorphism is widely prevalent in sexually reproducing organisms, such a consensus would suggest that either this diverse group exhibited a highly unusual biology or that research bias is at play. Here we show that so-called ‘species recognition’ and ‘mutual sexual selection’ hypotheses for non-avian dinosaurs are poor explanations, and that there are multiple lines of evidence for sexual selection and variation of structures consistent with secondary sexual characteristics. We also show how univariate significance testing approaches, especially tests for bimodality, are uninformative and prone to false negatives. Instead, we propose a novel methodology for studying sexual dimorphism in the fossil record that focuses on traits likely to be secondarily sexual and tests against all alternate hypotheses for variation in those traits using multiple lines of evidence. Notably, we utilize effect size statistical approaches that are appropriate for low sample sizes, rather than significance testing, to analyze potential divergence of growth curves in these traits, compute maximum and minimum estimates for dimorphism and gauge support for sex-based growth models. Thus, it is more appropriate to compare estimates for the magnitude of and support for dimorphism between datasets than to attempt to decisively reject or fail to reject dimorphism in a single species. This approach is shown for the study of sexual selection across phylogenies and time. We discuss our approach with both simulated and empirical crocodilian and avian data.

**Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM)**

**New Dinosaur, Pterosaur, and Crocodyliform Fossils from the Upper Cretaceous (Cenomanian) Bahariya Formation of the Bahariya Oasis, Egypt**

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The Upper Cretaceous (Cenomanian) Bahariya Formation of the Bahariya Oasis in the Egyptian Western Desert has yielded a diverse fossil vertebrate assemblage, including the type specimens of the non-avian theropods *Spinosaurus, Carcarchodontosaurus*, and *Bahariasaurus*; the titanosaurian sauropods *Paraltitan* and *Aegyptosaurus*, and the crocodyliforms *Libycosuchus, Stomatosuchus*, and *Aegyptosuchus*. Recent palaeontological fieldwork within the oasis has resulted in the discovery of new fossil
vertebrate-bearing localities in multiple horizons of the Baharya Formation. The recovered fossils, still under study, include the following: (1) a quadrate of an as-yet unidentified large-bodied archosaur, with a dorsomedial expansion, a relatively small pterygoid flange, and mediolaterally elongate articular condyles; (2) a well-preserved cervical vertebra of an abelisaurid theropod that is relatively short and that has a neural spine that is taller than its epipophyses, suggesting a robust neck comparable to those of the Patagonian abelisaurids Carnotaurus and Ekrixinatosaurus; (3) an associated partial skull of a medium-sized non-avian dinosaur, probably a juvenile sauropod; (4) a left first wing phalanx of a medium-sized pterosaur, which has an ossified, medium-sized extensor tendon process with a shallow, open saddle and that bears large cotyles with the posterior process at the proximal end of the phalanx suggesting tight articulation with metacarpal IV; and (5) a right dentary of a crocodyliform that possesses enlarged teeth in the first and fourth alveoli, with the latter followed by seven smaller teeth. These new discoveries include the first record of Pterosauria from Egypt and possibly the first definitive abelisaurid material from the Baharya Formation. Furthermore, the crocodyliform dentary appears to represent a taxon not previously reported from this stratigraphic unit, with potential affinities to Peirosauridae (including ‘trematothampсидs’) or Mahajangasuchidae.

Grant Information:
Mansoura University research fund and National Geographic Society Committee for Research and Exploration Grant 9144-12.

Technical Session II (Wednesday, October 9, 2019, 11:00 AM)
AN EXCEPTIONALLY PRESERVED SMALL-BODIED ORNITHOPOD DINOSAUR FROM THE LOWER CRETACEOUS (UPPER ALBIAN) WINTON FORMATION OF ISISFORD, CENTRAL-WESTERN QUEENSLAND, AUSTRALIA, AND THE DIVERSIFICATION OF GONDWANAN ORNITHOPODS

SALISBURY, Steven W., University of Queensland, Brisbane, Australia; HERNE, Matthew C., University of New England, Armidale, Australia; LAMANNA, Matthew C., Carnegie Museum of Natural History, Pittsburgh, PA, United States of America; NAIR, Jay P.; University of Queensland, Brisbane, Australia; SYME, Caitlin, University of Queensland, Brisbane, Australia; WITMER, Lawrence M., Ohio Univ, Athens, OH, United States of America

Ornithopod dinosaurs form a ubiquitous component of the Cretaceous continental vertebrate faunas of Australia. Although represented by numerous specimens from sites across southern Victoria, southwestern New South Wales, and parts of western Queensland, the majority of specimens is very incomplete. Of the named taxa, most (Ablascoposaurus, Galleemosaurus, Locaulynsaurus, Quintassaurus, Wewarsaurus) are based on craniodental remains, whereas others (Diluvicursor) are based on partial postcranial. The only still under study from both cranial and postcranial elements, Muttaburrasaurus, exhibits unusual morphologies that have rendered its affinities contentious. Unfortunately, the nature of Australian ornithopod material has long obfuscated the phylogenetic relationships of these dinosaurs and their relevance to broader patterns of ornithopod evolution and paleobiogeography.

Here we report a new ornithopod from the Lower Cretaceous (upper Albian) Winton Formation of Isisford, central-western Queensland, Australia. The new taxon is represented by a nearly complete skull and mandible and at least three partial postcranial skeletons. The material represents the most complete small-bodied ornithopod from Australia and includes one of the world’s best-preserved basal ornithopod skulls. The new form is the first non-dryomorphornithopod from Gondwana with an edentulous premaxilla; moreover, the antorbital fenestra is greatly reduced as in Muttaburrasaurus and styracosternans. The dentition is intermediate between that of Muttaburrasaurus and other small-bodied ornithopods from Australia and South America. Character and ilium and pes are shared with multiple Gondwanan Cretaceous ornithopods.

The Isisford taxon sheds new light on clade-level diversity at the base of Ornithopoda and helps resolve the relationships of Gondwanan non-hadrosauriform ornithopods. Phylogenetic analysis recovers the new taxon within a diverse clade of Gondwanan ornithopods that includes taxa from Australia, South America, and Antarctica and that is the sister taxon of the predominantly Laurasian Clydeodonta (Hypsilophodon + Iguanodontia). Gondwanan ornithopods diverged from clypeodontans during the Middle-Late Jurassic, with their greatest diversification likely to have occurred during the Cretaceous. Morphological diversity within the Gondwanan ornithopod radiation appears to mirror that of clypeodontans, encompassing small- to large-bodied forms, highlighting the potential for further discoveries.

Grant Information:
Australian Research Council; Land Rover Australia; ISISford, Longreach & Winton shire councils; Qld Museum; Carnegie Museum of Natural History, University of Queensland

Regular Poster Session III (Friday, October 11, 2019, 4:15 - 6:15 PM)
A NEW MIocene CROCODYLIFORM FROM THE ISLAND OF NOSy MAKAMBY, NORTHWESTERN MADAGASCAR

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Madagascar’s crocodyliform fossil record includes a diversity of bizarre Late Cretaceous basal mesoeucrocodylians and two Quaternary crocodylids - one that went extinct during the Holocene (Vouy robustus) and modern Crocodylus niloticus. The Late Cretaceous forms are unrelated to those of the Quaternary, and the near lack of Cenozoic vertebrate fossils obscures the origin and early evolution of historically extant Malagasy crocodylians. Recent discoveries from nearshore marine deposits have begun to clarify the Cenozoic histories for other groups, including sharks, bony fish, turtles, sirenians, and the island’s first fossil cetacean. We report here Miocene crocodyliform material from the island of Nosy Makamby, northwestern Madagascar, including osteoderms, vertebrae, a partial lower jaw, and anterior snout. It preserves a combination of character states inconsistent with any previously-described Malagasy crocodyliform. Unlike Late Cretaceous taxa, the vertebrae are prococelous. Unlike V. robustus and C. niloticus, the rostrum is slender with parallel lateral margins and the mandibular symphysis is extensive. This indicates a complex biogeographic history of Malagasy crocodyliforms, with multiple dispersal events following extinction of the Late Cretaceous fauna. The Nosy Makamby form is broadly similar to slender-snouted crocodylians from the Cenozoic of Africa (e.g., Eogavialis), although the anterior dentary alveolus show greater disparity in diameter and are not as evenly spaced in the Nosy Makamby form. A close relationship between African and Malagasy styracosternans could consist of an element with a marine, or at least marine-tolerant, origin for modern ghialinds, both of which only occur in fresh water.

Grant Information:
National Geographic Standard Grants (#NGS-1611-18, #9662-15, #8667-09, #8125-06, #7687-04)
CRANIAL ENDOCASTS OF COLUGOS, AND THEIR RELEVANCE TO UNDERSTANDING THE EARLY PHASES OF THE EVOLUTION OF THE BRAIN IN EUARCHONTA AND PRIMATES

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In order to better understand what is primitive in terms of the morphology of the brain for Primates it is essential to understand the form of the brain in primates’ closest extant relatives: Dermoptera (colugos) and Scandentia (treeshrews). Treeshrews are often viewed as modern proxies for early primates because they are small-bodied and have lissencephalic brains. However, a previous study concluded that the endocranial morphology of treeshrews is derived and unlike that of primitive primates (plesiadapiforms). Dermopterans are also extant animals, closely related to primates, albeit much larger than treeshrews and with gyrencephalic brains. Little is known about the endocranial morphology of colugos despite their important position in Euarchonta.

Although dermopteran endocasts contrast with those of scandentians in being gyrencephalic, the relative neocortical surface area (~36%) is within the range of Scandentia (33.6%-39.8%), similar to early fossil euprimates (e.g., 31-36% in apoids), and much higher than in plesiadapiforms (~20-22%). The olfactory bulbs are relatively smaller than observed in scandentians or plesiadapiforms, amounting for only 3.8% of the total volume; this is greater, however, than in apoids (1.2-2.4%). To examine patterns in shape, a set of 30 endocranial landmarks were placed on endocasts derived from microCT data for 22 treeshrews: *Ptilocercus* (n=5), *Tupaia* (n=15), and *Dendrogale* (n=2), both species of dermopterans: *Cynocephalus volans* (n=1) and *Galeopterus variegatus* (n=1), and two plesiadapiforms: *Ignacius graybullianus* (n=1) and *Microsyops annecottae* (n=1). Procrustes shape variables were examined in a Principal Components Analysis. The results show that dermopterans occupy their own position both in treeshrews and plesiadapiforms. This is largely due to differences in the overall shape of the cerebellum and due to an anterior-dorsal shift in the highest point of the neocortex. These results highlight the distinctive nature of the dermopteran endocast, which lacks clear similarities in shape or proportion to those of plesiadapiforms. Although there are some general resemblances to early euprimates, these similarities are in features are either very prone to parallelism (e.g., reduction in the size of the olfactory bulbs) or are likely related to increased overall size (e.g., presence of neocortical sulci). These results highlight the problematic nature of using modern taxa as models for the early phases of primate or euarchontan brain evolution.

Grant Information:
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A NEW RHAETIAN BONEBED FROM GERMANY: IMPLICATIONS FOR THE END-TRIASSIC EXTINCTIONS IN THE MARINE REALM

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The mass extinction at the end of the Triassic is arguably the least understood of the Big Five extinction events, partially because of dating and correlation issues and partially because of scarce Rhaetian fossil localities. Among these, the classical Rhaetian bonebeds (condensation horizons) of the European marine epicontinental Triassic have been important because of their taxonomic sampling from facies to terrestrial environments. Yet, the stratigraphic position of these bonebeds relative to the Triassic-Jurassic boundary is well constrained. The newly discovered Rhaetian bonebeds of Bonenberg (eastern Westphalia, Germany) improve this situation by their biostratigraphically (palyonomorphs, chonchostracans) well constrained late Rhaetian age combined with an abundant and diverse terrestrial fauna. In Bonenberg also provides a thick Triassic-Jurassic boundary section, including the latest Triassic (201.5 ma) Event Beds which directly overlie the bonebed. Among the fish remains, chondrichthyan teeth and fin spines represent typical Rhaetian taxa (e.g., *Graziosodon candae*, *Lissodus minimus*, *Hyodus cloacinus*, *Nemacanthus montifer*, and *Rhombobrachidion minor*) which do not survive into the Jurassic. Large *Ceratodus* sp. lungfish teeth record continental input. Tetrapods are represented not only by amniotes, but surprisingly also by temnospondyls. Plagiostomids are common, and abundant remains of large capitosaurid temnospondyls are the youngest record globally. Amniotes are represented by ichthyosaurs, sauropterygians, the possible cheirosternid *Fuchysphene*, saurischian dinosaurs, and the crocodylomorph *Lepagia*. The most abundant ichthyosaur remains are extremely short (length < 20% of height) but large vertebral of the *Shonisaurus* type and the cortical fragments of giant ichthyosaur jaw bones. Sauropterygians are represented by at least three taxa of plesiosaur including *Rhaetosaurus*, but also by non-plesiosaurian pistoroasaurids such as a large (30 cm) humerus and vertebrae.

The Bonenburg faunal record thus offers a contradictory signal regarding the nature and severity of the extinctions. The finds indicate that many chondrichthyan, two clades of non-brachiopoid temnospondyls and giant shastasarid ichthyosaurs survived into the latest Triassic but not beyond. Non-plesiosaurian sauropterygians also went extinct, but plesiosaurs seem to have suffered little. In summary, the extinctions appear to have been sudden, constrained to the latest Triassic Event Beds, but selective.

Grant Information:
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A REVIEW OF AFRICAN ELSAMOTHERES (MAMMALIA, RHINOCEROTIDAE) AND THEIR ROLE ON EARLY MIOCENE MIGRATION EVENTS INTO EAST AFRICA

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Rhinoceroses first ventured into Africa at the early Miocene. By the beginning of the middle Miocene, all the main clades recorded in Eurasia were already represented across East Africa by a series of endemic species, pointing to a critical period of rhinoceros evolution at a continental level. These include members of the Elasmotherina, rhinoceroses with a highly hypsodont dentition and a conservative postcranial skeleton. We studied the holotype of *Tyrkanatherium acutirostratum*, the first elasmotheriace species reported from the continent. The skull comes from the early Miocene (16.8–17.5 Ma) strata of the Monsorot Hill, Kenya, and is housed at the National Museum of Colombo, Sri Lanka, where has not been accessed by specialists for the last 65 years. Previous studies proposed the presence of a long-lasting lineage of African elasmotheres. Our detailed re-description and revised diagnosis of *T. acutirostratum* not only confirms its elasmothere affinities but also shows that African Elasmotherina species are related to separate Eurasian clades. The lineage leading to *T. acutirostratum* is part of a distinct early Miocene migration event separated from that of *Ougandatherium napakense*, an earlier elasmotheriace species found in the early Miocene deposits of Napak (Uganda). However, East African elasmotheres postcranial remains poorly known, highlighting the need for their study in order to elucidate the distribution of the group at a continental level. This work highlights the role of Rhinocerotidae in the strong but progressive faunal turnover event taking place in East Africa for much of the Miocene.

Grant Information:
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THINK BIG, EVOLUTIONARY ALLOMETRY AS A MAJOR FACTOR IN RATES OF MORPHOLOGICAL EVOLUTION OF THE PRIMATE BRAIN SHAPE

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Primates constitute one of the most successful and diverse mammalian clades. One key factor in their diversification is the evolution of their peculiar brain morphology, however, the evolutionary and developmental processes determining the relevant shape changes in the primate brain remains largely unknown. In this study we used 3D geometric morphometrics, phylogenetic comparative methods and Bookstein’s novel concept of scaling in shape
variation to understand the factors influencing rates, trajectories and scaling of brain shape in a sample of 152 species (147 extant and 5 extinct) including members from each major primate clade (including Homo sapiens and the omomyid taxon *Rooneya*). We found only Hominioidea and Cercopithecoidea showed a significant evolutionary allometry after controlling for phylogeny, whereas Strepsirhini, Colobinae and Platyrrhini did not. However, Hominioidea and Cercopithecoidea both showed markedly higher rates of morphological evolution, whereas Strepsirhini and Platyrrhini display a significant slowdown. As a consequence, Hominioidea and Cercopithecoidea have different trajectories and magnitudes of shape changes when compared with the remaining clades. Apes, lesser apes and cercopiths tend to have an overall globular brain shape with more developed frontal lobes. Furthermore, there is a large-scale effect (global pattern of variation) of size on brain shape in Hominioidea and Cercopithecoidea, whereas size better describes smaller scales of variation (local pattern) in the slowly evolving clades. In conclusion, our results suggest that the evolution of allometry may have favored shape changes at larger scales and promoted the rapid evolution exhibited by Hominioidea and Cercopithecoidea. On the other hand, the smaller scale effect of size on brain shape of Strepsirhini and Platyrrhini might have had a key role in their reduced evolutionary rates.

Education and Outreach Poster Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)

COSPLAY FOR SCIENCE: UTILIZING POP CULTURE NARRATIVES AS A MEANS FOR SCIENCE EDUCATION OUTSIDE TRADITIONAL LEARNING CENTERS

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The intersection of popular culture and science is often not considered by the general public, yet narratives produced by popular culture have been an incredibly effective avenue when introducing scientific concepts into general knowledge. Multimedia franchises like the Jurassic Park series, Walking With Dinosaurs, and Arc: Survival Evolved have exposed audiences to palatable paleontological concepts and have brought dinosaur taxa into common vernacular. While not often accurate in portrayals, the scientific concepts intertwined through these narratives can be used as starting points for engagement through informal science education with general audiences fostered by their familiarity. Cosplay for Science is a STEAM-powered science communication initiative created to employ well-known pop culture narratives as a means to make science education concepts more relatable and accessible, entice a broader audience, and allow scientists to be more approachable. Through the use of online media and in-person engagements, such as pop-up museums, Cosplay for Science events aim to highlight how science intersects with pop culture in high-traffic spaces not traditionally used for education. Cosplay for Science members aim to benefit from the familiarity and popularity of pop culture franchises with charismatic creatures such as dinosaurs to develop audience’s appreciation for paleontology and natural history museums, and encourage audiences to think critically about science topics in their everyday lives by utilizing these inherent interests in unique delivery methods. Additionally, through the use of qualitative and quantitative surveys with audiences at our in-person engagements, the Cosplay for Science Initiative looks to study how pop culture influences audiences’ perceptions of science and develop best practices for utilizing it in science communication and education.

Preparators’ Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)

A PRACTICAL GUIDE TO START A NEW VERTEBRATE FOSSIL PREPARATION LAB

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After field collections and acquisition of specimens, fossil preparation is the crucial next step in the conservation of fossil specimens for research, collection, exhibition, and education. Proper and safe fossil preparation requires a well-equipped laboratory that is supplied with a variety of mechanical equipment, hand tools, and chemical supplies. Starting a new fossil preparation lab is a challenging task, especially for institutions in which space is limited, and in developing countries with limited budget and without an experienced preparator. In order to facilitate the difficulties associated with planning to start a new lab, we have developed a practical guide with a categorized list of items.

A list containing about 50 basic items was made with the purpose to start a preparation lab for a museum in China in 2011. Over the years, preparation labs were built at three museums, more items were added as projects in the labs expanded and the list became extensive after several revisions. The current list contains over 180 categorized items. Categories include a general lab environment, tools for work stations, safety equipment, matrix removal, acid preparation, molding/casting, and conservation. This list serves as a useful guide to aid in selecting items to start a new lab based on the type of preparation and conservation work performed according to institutional needs. It is important for an institution to identify the techniques and materials required to prepare different types of fossil specimens and various modes of preservation so that the lab can be equipped accordingly for the tasks at hand. Different tasks require different supplies. For example, if the majority of lab work focuses on manual and mechanical preparation, then the lab should be equipped with items from the ‘lab environment’, ‘work station’, ‘safety equipment’, and ‘acid preparation’ sections. Subcategories are also useful to guide selecting specialized materials and equipment suited for a particular project, such as macro preparation involving large sauropod elements in coarse sandstone which would require a high-powered binocular stereo microscope and a pin vise fitted with a carbide rod. As a different task is assigned, lab personnel can plan a budget to purchase items from the appropriate category. This guide is a practical reference for starting and expanding a vertebrate fossil preparation lab.

Technical Session XII (Friday, October 11, 2019, 11:00 AM)

LONGEVITY AND GROWTH DYNAMICS OF TRICERATOPS AS REVEALED BY FEMORAL HISTOLOGY

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The chasmosaurine ceratopsid *Triceratops* underwent dramatic cranial changes through ontogeny, particularly in the postorbital horn cores (from caudally to rostrally curved), flattening of initially delta-shaped frill epiossifications, and expansion and fenestration of the parietal-squamosal frill. Studies of postorbital horn core histology reveal bone remodeling and secondary osteon density is positively correlated with cranial changes, providing a means for determining relative maturity and validation of the hypothesized cranial growth trajectory. Due to aggressive remodeling, postorbital horn cores do not preserve an absolute record of ontogenetic maturity. Here we present the results of the first histologic sampling of six *Triceratops* femora associated with cranial material and correlate ontogenetic skull morphologies with absolute individual ages.

The smallest specimen sampled, MOR 2951, is a juvenile with a basal skull length (BSL) of 58.6 cm, caudally curved postorbital horn cores, and a femoral circumference (FC) of approximately 21 cm. This specimen preserves one cyclical growth mark and was approaching the end of its second year at death. One large subadult specimen, MOR 3027, with a BSL of 110 cm and an FC of approximately 43 cm, preserves seven to eight annuli and a distinct external remodeling. Variation in the extent of remodeling and relative maturity is noted between the histology of more mature specimens. MOR 2982, a specimen with a BSL of 100 cm, subtriangular epiparietals, and a FC of approximately 43 cm, preserves seven to eight annuli and a distinct external fundamental system (EFS). While MOR 2702, a larger individual with procured horn cores, a BSL of 121 cm, and a FC of 54 cm, preserves at least 11 annuli and no clear EFS. MOR 10843 is the most ontogenetically mature specimen sampled; it has a procured postorbital horn core, and a femoral circumference of approximately 49 cm. The MOR 10843 femur preserves dense secondary remodeling and a thick EFS; many erosion rooms throughout the cortex show remodeling was ongoing at death.

This study confirms the utility of cranial morphological features for determining relative maturity in *Triceratops* and demonstrates that body size does not always correlate with absolute age. *Triceratops* lived for at least 11 years, but determining the extent of its lifespan beyond this point may be complicated by dense bone remodeling. Continued histological sampling of additional specimens will further illuminate growth dynamics in *Triceratops*.
THE FIRST KNOWN FOSSIL OF UMA DEMONSTRATES EXAPTATION AND ECOLOGICAL EVOLUTION IN A SPECIALIZED CLADE

SCARPETTA, Simon G., University of Texas at Austin, Austin, TX, United States of America

Evidence from the fossil record suggests that extant lizard genera of North America (north of Mexico) evolved during the Miocene. Although fossils of Phrynosomatidae (fence lizards, sand lizards, and horned lizards) were previously described, there are no known fossils of the fringe-toed sand lizards (Uma). Uma are restricted to fine-grained sandy habitats but already displayed one of the complex. The crown clade of Uma in the Miocene strata of the Dove Spring Formation in southern California, dating to 8.77 Ma. The fossil is a premaxilla and partially preserves the shape of the shovel-shaped snout of extant Uma species, which is used to accelerate sand burial by extant Uma. I estimated new divergence times for Uma and related phrynosomatid lizards using molecular data and five fossil calibrations, including the new fossil. The new divergence times provide a temporal context for the evolution of Uma and for the divergence of Uma scoparia from the Uma notata complex. The crown clade of Uma evolved in the early to middle Miocene, and the west clade of Uma evolved in the late Miocene to middle Pliocene. The paleoenvironment of the Dove Spring Formation was semiarid and contained ephemeral streams, but there is no evidence of sand dune deposits from which the Uma fossil was found. In their early history, Uma were not restricted to fine-grained sandy habitats but already displayed one of the morphological correlates of living in sand. I recommend exercising caution when using environmental tolerances and morphological features of extant taxa to hypothesize paleoecological reconstructions.

Grant Information:
Geological Society of America (GSA) student grant
Jackson School of Geosciences, University of Texas at Austin

INNER EAR ORIENTATION REFLECTS HEAD POSTURE IN THE WOOLLY RHINO (PERISSODACTyla: RHINOCerotidae)

SCHELLHORN, Rico, Universität Bonn, Bonn, Germany

During the Pleistocene a climatic fluctuation occurred between colder glacial and warmer interglacial periods in Eurasia. Each period showed distinct floral and faunal elements adapted to the particular climatic conditions. Beside the woolly mammoth, the woolly rhinoceros (Coelodonta antiquitatis) was an important member of the Pleistocene herbivore megafauna. Both taxa were adapted to the cold temperatures of the glacial periods. Mummies from Siberia and Ukraine provide an exceptional insight in the paleobiology of the woolly rhinoceros, much better than reconstructions from solely fossil bones. Stomach and urinary bladders were recorded during a three month period. Animals were provided a range of vegetation. The nasal horns were abraded because they were used to remove the snow cover from low growing plants on the ground. This specific feeding habit targeted new vegetation in areas with existing vegetation, which is also expressed in the plant food intake. The woolly rhino like the modern grazing white rhinoceros from the African continent shows a downward oriented head posture. This is reflected by the backward inclined occipital crest of the skull, which is seen in both the woolly rhino and the extant white rhino. In this study different skulls of the woolly rhino from different German localities were scanned using micro-computed tomography to reveal the orientation of the bony labyrinth inside the petrosal bone. The endocast of the inner ear was reconstructed digitally to make the position of the semicircular canals visible. As a premise, it is assumed that the lateral semicircular canal is oriented horizontally in the habitual head posture of mammals. The reconstructed lateral semicircular canals of both petrosals of each skull was aligned to a horizontal plane to calculate the habitual head posture using the orientation of the inner ear within the skull. As a result, the skulls of the woolly rhino show a downgraded head posture. This approach was initially tested using extant rhino skulls, resulting in a downgraded head posture for the grazing white rhino. Thus, beside the shape of the occipital region of the skull, the orientation of the inner ear can be used to reconstruct the habitual head posture (and therefore feeding preferences) in fossil (and extant) rhinos.

Grant Information:
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ANGOLA AND ITS ROLE IN THE PALEOBIOGEOGRAPHY OF GONDWANA

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POLLICYN, Mike, Dallas, TX, United States of America; GONÇALVES, António Olimpio, Universidade Agostinho Neto, Luanda, Angola; JACOBS, Louis L., Southern Methodist Univ, Dallas, TX, United States of America

Tectonic rifting of Africa from South America began by 131 Ma. The rifting of Africa and South America allowed communication of flood plain and terrestrial biota, including fish, crocodilians, and piscivorous dolphins between what is now Africa and South America during the Early Cretaceous. Marine Boring and more open ocean conditions were initiated in the central South Atlantic by the late Aptian (113 Ma), interrupting the terrestrial biome. With the opening of the Equatorial Atlantic Gateway by 90 Ma (Turonian), bottom water flowed north to cool global oceans. Mosasauers entered the central South Atlantic from the Tethyan Province and plesiosaurs entered from the southern Weddellian Province. Our excavations in Angola, ongoing for almost 15 years now, have documented these developments, and show that coastal upwelling traced along the southwestern continental margin as Africa drifted north during the Late Cretaceous and Cenozoic. The Cretaceous rich upwelling ecosystem along what is now Angola gave way, following the Cretaceous-Paleogene extinction event, to a Cenozoic upwelling system increasingly centered on marine turtle, which became fully established, apparently with the parameters now observed, in the Late Miocene around 10 Ma. Marine turtles are the only amniotes to inhabit both the Cretaceous and Cenozoic phases of this upwelling ecosystem. Northward drift of Africa that shifted the position of upwelling along the African coast concomitantly also shifted the position of the associated hyperarid coastal desert that now is the refuge for the enigmatic gnetal plant Welwitschia. The paleogeographic position of southern Africa since the Miocene established the modern environmental conditions of the Namibian Desert and Benguela Current, and induced development of the hyperdiverse Cape Flora and related biological hotspots in southern Africa.
differences in biting and masticatory behavior. This new observation can be useful for understanding the dietary differences within mammaliforms. The mammal molar wear patterns are distinct and directly related to food mastication, the chewing movements calculated from occlusal fingerprint analyses of a variety of mammaliforms can now be tested by XROMM examination of extant mammals.

Grant Information:
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Technical Session VII (Thursday, October 10, 2019, 8:00 AM)

BACK TO THE SEA – ADAPTATIONS OF THE TYMPANIC SYSTEM IN THALATTOSUCHIAN CROCODYLOMORPHS

SCHWAB, Julia A., University of Edinburgh, Edinburgh, United Kingdom; HERRERA, Yanina, Facultad de Ciencias Naturales y Museo, La Plata, Argentina; DOLLMAN, Kathleen, University of the Witwatersrand, Johannesburg, South Africa; BRUSATTE, Stephen, University of Edinburgh, Edinburgh, United Kingdom

Cranial sensory organs are a powerful ecological proxy, and give unique insights into animal behaviour and lifestyles. One of these sensory organs is the otic region, comprising the inner and middle ear as well as the tympanic air space. The inner ear includes the membranous and the bony labyrinth, and besides its involvement in hearing, it is also involved in equilibrium and head stabilisation. Such sensory organs also played a key role in major evolutionary and environmental transitions within vertebrates. We here study one group, thalattosuchian crocodylomorphs, that underwent a major transition, evolving from terrestrial ancestors into pelagic marine species during the Jurassic. Their osteological changes are well known, such as their development of paddle-shaped limbs, loss of osteoderms, and a species during the Jurassic. Therefore evolved before pelagornithids became highly specialized gliders. The new species furthermore suggests that pelagornithids evolved in the Southern Hemisphere and documents a very early radiation of neornithine seabirds, which may have been triggered by changes in marine ecosystems at the end of the Mesozoic.

Grant Information:
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Regular Poster Session I (Wednesday, October 9, 2019, 4:15 - 6:15 PM)

NORTHERNMOST RECORD OF LANCIAN (LATEST CRETACEOUS) MAMMALS

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Mammals of Late Cretaceous (Aquilian-Lancian) age are well known from western Canada, and provide an important record of mammalian evolution throughout a substantial part of the Late Cretaceous. When placed in the larger context of vertebrate faunas, they provide a better understanding of how vertebrate communities responded to a dynamic period in Earth history. We report here on a new locality in western Alberta, 80 km north of the hamlet of Grande Cache, that preserves the remains of mammals and other vertebrates. The locality occurs at a cutbank of the Kakwa River, where rocks of the Upper Cretaceous Coalspur Formation are exposed. Exposed bedrock consists of ripple-laminated and cross-bedded fine-grained sandstones, organic rich mudstones, shales, and sub-bituminous coals containing thin bentonites, as well as pockets of fossil mollusks, coalified wood, and leaf fragments, all suggestive of deposition in an ancient alluvial wetland. The vertebrate fauna is dominated by scales, teeth, and bones of bony fish, but also includes rare lizard and theropod dinosaur teeth, as well as those of several mammalian taxa. Two multituberculates have been identified (Mesoconia cf. M. hensleighi, and a probable cimolomyid), as well as three marsupials (Proplodontia cf. P. florencae, Pedionomys cf. P. elegans, and a new pedionomid), and one eutherian (Gymnognathus cf. G. illimunatus). Although presently small, the mammalian fauna is nonetheless most consistent with those from Lancian localities at more southern latitudes in the North American Western Interior. A palynomorphic sample from immediately above the vertebrate horizon preserves an assemblage that is likely correlated with the Triprojectus quadriracreatus-Bratzevaea amurensis Biozone immediately preceding the K-Pg boundary, a result that is congruent with the mammalian evidence. The new locality occurs some 280 km north of the KUA-1 locality in south central Alberta, and at nearly 55 degrees latitude—with a projected paleolatitude of approximately 62 degrees—documents the northermost occurrence of Lancian mammals to date. Given the paucity of Lancian faunas in western Canada, the new locality is a welcome addition to the record of Late Cretaceous mammals. Its high latitude and stratigraphic proximity to the K-Pg boundary offer a unique perspective on mammalian and other vertebrate assemblages just prior to the end-Cretaceous extinction event.

Technical Session IV (Wednesday, October 9, 2019, 3:30 PM)

COMPLEXITY OF THE LOWER MOLAR ROW IS EXPLAINED BY THE INHIBITORY CASCADE MODEL AND DIET WITHIN EUARCHONTA

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The inhibitory cascade model (ICM) postulates that molar morphogenesis in mammals follows a ratcheting pattern, with the development of M1 inhibiting
that of M2, and that of M2 inhibiting M3. It is currently unknown if the development of molar complexity in euarchontans follows the ICM, and how inhibition affects euarchontans with different diets. The ICM predicts that M3/M1 complexity regressed on that of M2/M1 should result in a linear regression with a slope of 2.0 and an intercept of -1.0. Previous work has shown that high molar complexity provides a functional advantage for folivores and insectivores; such taxa are predicted to show a linear increase in complexity moving distally among molars as inhibition should be weak. Frugivores are predicted to show the opposite pattern, with a decrease in complexity moving distally, as high complexity is not as necessary to process less mechanically challenging food.

We measured Orientation Patch Count Rotated and surface area of the lower Frugivores are predicted to show the opposite pattern, with a decrease in the molar row. The frugivores show high inhibition of complexity in the molar row, while the folivores and insectivores show low inhibition and a linear increase in complexity from M1 to M3. These patterns are independent of molar size, as mean M3 surface area is lowest in the molar row for each dietary guild. The development of molar complexity is in part controlled by the sonic hedgehog pathway, which affects the cascading pattern of molar size. This pathway, as well as others, may provide a mechanism for the selection of molar complexity within different dietary guilds. Our findings suggest a simple rule of inhibitory dynamics may control the evolution/development of molar complexity in Euarchonta, where selection needs only act upon the complexity of M1 to change that of distal molars. This model may therefore provide a framework to understand fundamental shifts in molar morphology in euarchontan evolution, which may be more broadly applicable in Mammalia.

Grant Information: This research was supported by a NSERC Discovery Grant and a UTSC International Research Collaboration Fund award to MTS.

Technical Session VII (Thursday, October 10, 2019, 9:30 AM)

AN AGILE UNARMORED NOTOSUCHIAN FROM CENOMANIAN-AGE ROCKS IN NIGER INITIATE THE PARTITIONING OF THE GONDWANAN PLEXUS OF ARARIPESUCHUS SPECIES

SERENO, Paul C., University of Chicago, Chicago, IL, United States of America; POL, Diego, Museo Paleontologico Egidio Feruglio, Trelew, Argentina

A new slender-limbed notosuchian is described from Cenomanian-age rocks in Niger. The single, and only known, adult specimen preserves in articulation the cranial and lower jaw, the axial column to the mid dorsal vertebrae, and the pectoral girdle and most of the forelimb. More posterior portions of the axial column including sacral and caudal vertebrae and portions of the pelvic girdle and both hind limbs suggest that the skeleton was very complete and articulated when originally buried. However, not a single osteoderm is preserved, and the cranium, furthermore, lacks the pitted texture that characterizes nearly all other crocodylomorphs. The new taxon is allied with Araripesuchus tsangatsangana from Madagascar, and has the same paleogeographic link to Madagascar as its contemporary, the fanged Araripesuchus. The Malagasy araripesuchid, furthermore, also shows little evidence of dorsal osteoderms, despite the recovery of multiple, semi-articulated specimens from a single locality as well as the presence in the same formation of Simosuchus with its extraordinary osteoderm sheathing. We reconstruct the new species as one of the most erect, long-limbed notosuchians of all, a striking departure from the previous reconstruction of A. tsangatsangana as semi-erect with a full complement of parasagittal dorsal osteoderms. The new species, as well as additional remains of the older A. wegeneri from Niger, provide new evidence to tease apart the paraptyelic assemblage of Gondwanan species currently assigned to Araripesuchus.

The size of the principal nutrient foramen on long bones can indicate the size of the nutrient artery and hence an index of blood flow rate (Q) to the bone shaft. Because blood flow is essential for bone remodelling to repair micro-fractures caused by locomotion, the foramen size and Qi are functionally related to the level of locomotion. In extant mammals, for example, Qi increases with body mass with an exponent of 0.86, which is almost indistinguishable from the exponent (0.87) for exercise-induced maximum aerobic metabolic rate. Extant non-avian reptiles, which generally do not remodel their long bones, have Qi values about 10 times lower than mammals, and considering their low blood pressure, bone perfusion is about 50 times lower. Extant bipedal cursorial birds have Qi values that also scale with body mass to the 0.89 power, but are almost twice the values for cursorial quadrupedal mammals, because bipeds place about twice the weight on their femora, compared to quadrupeds. These results for living animals show how the size of the nutrient foramen relates to intensity of locomotion. Nutrient foramina on well-preserved fossil femora can be photographed, measured and compared to data from living species. We searched world collections and sampled about 200 fossil femora with preserved foramina. The present study is based on 34 specimens of Triassic, non-archosaurian archosauromorphs and pseudosuchians, dating from 250 Mya to 48 Mya. The Qi values for these animals are not significantly different from extant mammals and birds, and reveal a similar scaling exponent of 0.90. They are significantly above the Qi data for extant non-avian reptiles, which are ectothermic and rely extensively on anaerobic metabolism during brief bouts of intense activity. These results support the hypothesis that the crocodylian lineage of archosaurs were originally highly active animals, relying on aerobic metabolism for sustained locomotion. They required high rates of blood flow to all parts of the body, including the bones. These results complement the cardiovascular evidence of a previously enigmatic, 4-chambered heart in extant ectothermic crocodiles. A completely divided heart is essential for high aerobic metabolic rates in birds and mammals to separate systemic and pulmonary blood pressures and pump oxygenated blood at high rates to the tissues. As a result, the evidence bolsters the idea that the heart morphology in extant crocodiles is a retention of an ancestral trait that no longer functions to support endothermy.

Grant Information: Partly funded by the Australian Research Council (DP-12012081).

Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM)

RECORDS OF VERTEBRATE REMAINS FROM THE LATE TRIASSIC TIKI FORMATION, MADHIYA PRADESH, INDIA: IMPLICATIONS ON GONDWANA PALEOBIOGEOGRAPHY

SHARMA, Kongrajlalpat M., Central University of Punjab Bathinda, BHATIINDA, India; SINGH, Yumlembam P., Central University of Punjab Bathinda, BHATIINDA, India; SINGH, Nongmaithem A., Central University of Punjab Bathinda, BHATIINDA, India

The Tiki Formation is well known for its rich vertebrate fossils of Late Triassic (Carnian) age. The sanstone, siltstone and mudstone sequence of Tiki Formation during 2016-2018 could recovered certain mega-vertebrate remains comprising of rhynchosaurs, paracynodonts, phytosaurs, paracynodonts, rauisuchids, tiakisuchids, etc.; numerous microvertebrates represented by advanced cynodont Rewaconodon, the fish remains of elasmobranch sharks such as Xenacanthus xenacanthids, Northeasteanichthys indicus and Mesoeucodus jaini and Hypodus hybodonts Lonchidion estesi, L. incbens, Lissodius duffini and Parvodus tikensis as well as diponon fish Ceratodus sp;
The Paleogene followed a catastrophic mass extinction and the abolition of complex ecosystems dominated by non-avian dinosaurs and heralded the Age of Mammals. The Paleogene mammal fauna is perceived from two standpoints: on the one hand, it is a classic adaptive radiation marked by the proliferation of eutherian mammals, more ‘advanced’ than their Mesozoic ancestors; on the other, Paleogene taxa are considered ‘archaic’ compared with their extant relations. Seldom are Paleogene taxa considered for their own objective merit. Here, we investigate the locomotor behaviors of Paleogene mammals using a suite of multivariate and statistical analyses.

We compiled a dataset of 29 tarsal measurements for 36 Paleogene taxa alongside a sample of 69 extant thernal mammals of known locomotor mode and five Mesozoic cladotherians. Functional indices of the skeleton show Paleogene taxa to be significantly more robust than extant and Mesozoic species. A linear discriminant analysis classified the locomotor mode of 88.41% of extant species correctly. All Mesozoic taxa were classified as semi-fossorial. Principal Components Analysis show Paleogene taxa to be separated from the extant and Mesozoic, with the greatest disparity from the extant and Mesozoic taxa in different ecosystems which might have served a relatively rapid intercontinental passage of the vertebrate community extending across the ancient Supercontinent, Pangaea.

Grant Information:

KM Sharma is thankful to UGC for UGC Start Up grant sanction order No.F.30-4/2014 (BSR) and DST-SERB for Early Career grant sanction order no. ECR/2016/001100.

Technical Session XVIII (Saturday, October 12, 2019, 3:15 PM)

HIGH LOCOMOTOR DIVERSITY IN EARLY PALEOGENE MAMMALS PROVIDES ECOMORPHOLOGICAL INSIGHT INTO EVOLUTION FOLLOWING THE END-CRETACEOUS MASS EXTINCTION.

SHELLEY, Sarah L., Carnegie Museum of Natural History, Pittsburgh, PA, United States of America; BRUSATTE, Stephen, University of Edinburgh, Edinburgh, United Kingdom; WILLIAMSON, Thomas E., New Mexico Museum of Natural History, Albuquerque, NM, United States of America

The Paleogene followed a catastrophic mass extinction and the abolition of complex ecosystems dominated by non-avian dinosaurs and heralded the Age of Mammals. The Paleogene mammal fauna is perceived from two standpoints: on the one hand, it is a classic adaptive radiation marked by the proliferation of eutherian mammals, more ‘advanced’ than their Mesozoic ancestors; on the other, Paleogene taxa are considered ‘archaic’ compared with their extant relations. Seldom are Paleogene taxa considered for their own objective merit. Here, we investigate the locomotor behaviors of Paleogene mammals using a suite of multivariate and statistical analyses.

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Grant Information:

KM Sharma is thankful to UGC for UGC Start Up grant sanction order No.F.30-4/2014 (BSR) and DST-SERB for Early Career grant sanction order no. ECR/2016/001100.
DOUBLE-SCANNING AND GAUSSIAN BLURRING IMPROVE QUALITY OF PALEONTOLOGICAL CT DATA: EXPERIMENTS WITH TWO MAMMOTH TUSKS

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High-resolution computed tomography (CT) provides paleontologists access to information about specimens that was unattainable until recently. Because fossils consist primarily of mineralized hard parts of ancient organisms, often in a rock matrix, paleontological scanning requires high X-ray energies, which tend to decrease contrast in the resulting scans. Therefore, reduction in noise and enhancement of features is critical for paleontological CT applications. The simplest means of reducing noise is by averaging data from consecutive slices in a CT image stack. More control over this type of combination is possible with a blur function in three dimensions, which permits different weighting of data averaged from nearby voxels in different dimensions, rather than an unweighted average between consecutive slices. Applying a Gaussian blur to our scans altered the original data but permitted recovery of information on features that were otherwise easily misidentified, unidentifiable, or unmeasurable. We measured annual increments of tusk dentin from a mammoth from Mal’ Lyakhovskiy Island, in the Siberian Arctic, using the modified data to recognize life history patterns that were indecipherable in the noisier raw data. We attempted a second method of feature enhancement in the tusk of Yuka, a juvenile mammoth from the northern coast of Yakutia. By scanning the same tusk twice and adding the scans together, we were able to suppress some noise and known artifacts of reconstruction without losing resolution or otherwise compromising the data, revealing measurable growth features within the tusk that were obscured by noise and artifacts in the unmodified data. This methodology may further enhance features by combining scans taken at different X-ray energies to distinguish nearly identical radiodense materials from one another based on differential absorption of radiation related to density and atomic number. Controlled 3-dimensional blurs and double-scanning have merit beyond the realm of Quaternary mammoth tusks, and may be instrumental in clarifying features of older fossils with more extensive diagenetic alteration.

VERTEBRATE PALEONTOLOGY OF THE LOWER TRIASSIC FREMOUNW FORMATION IN THE SHACKLETON GLACIER AREA (ANTARCTICA)

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Rocks of the Transantarctic Mountains exposed in the area of the Shackleton Glacier were first investigated by vertebrate paleontologists during the 1970-1971 austral summer. Tetrapod fossils (e.g., *Lapillopsis*, *Procrothepson*, and *Tethysaurodon*) collected from the lower member of the Fremouw Formation were a critical link to coeval assemblages from the Karoo Basin of South Africa and elsewhere and provided compelling evidence that Antarctica once formed part of Pangaea. Historic localities such as Halfmoon Bluff, Kitching Ridge, and Shenk Peak, and *Tethysaurodon* provided the bulk of the geological and paleontological information about the Lower Triassic of Antarctica, but have received little attention since their initial discovery almost 50 years ago. In 2017, we conducted four weeks of helicopter-assisted fieldwork in the Shackleton Glacier area, which led to more precise geographical and geological data for old quarries as well as the discovery of new fossil localities that yielded well over 200 specimens. Newly measured stratigraphic sections suggest that vertebrate fossils of the lower Fremouw Formation primarily occur in crevasse splay deposits, characteristic of a meandering fluvial environment. The wackestone subunits contain abundant siliceous root traces and relict ripple cross laminations, suggesting early phases of soil development on the floodplain (i.e., Protosol). Isolated bones often occur in intraformational conglomerates and form the base of the formation, interbedded with large channel-fill trough cross-bedded sandstones. Footprints and trackways were rarely encountered in floodplain deposits, but large diameter sand-filled burrow casts (14 cm across) were occasionally locally abundant. Vertebrate fossils include isolated elements and partially articulated individuals preserving remarkable detail. Importantly, we collected the first diagnostic tetrapod material from the middle member of the Fremouw Formation. Although preparation is ongoing, our initial identifications suggest that both the lower and middle members are likely Lower Triassic, indicating broad-scale correlation to the Katberg Formation of South Africa. Interestingly, small temnospondyls are an important component of the middle Fremouw assemblage and likely represent a species allied with *Lapillopsis* from the Lower Triassic Arcadia Formation of Australia.

Grant Information: NSF-PLR-1341304; NSF-PLR-1341376; NSF-PLR-1341475; NSF-PLR-1341645

REPTILE MACROEVOLUTIONARY DYNAMICS ACROSS THE PERMIAN-TRIASSIC MASS EXTINCTION AND THE EMERGENCE OF NEW BODY PLANS

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Mass extinctions are unique periods in the history of life, capable of replacing entire faunas by new emerging evolutionary lineages and resetting ecological niche structure. Importantly, mass extinctions provide natural experiments to understand how fast environmental shifts may cause substantial changes on the diversity of phenotypic traits (morphological disparity) and the speed of evolutionary change, besides indicating how long it takes for lineages to recover from global level climatic disruptions. However, few studies have assessed large-scale dynamics of trait evolution among terrestrial vertebrates, and even fewer among reptiles, during the largest mass extinction in the history of complex life: the Permain-Triassic Mass extinction (PTME). Here, we utilize morphological and molecular data sampled across various families of squamates (lizards and snakes), along with morphological data from several early diverging diapsid reptiles to assess the rates of morphological and molecular evolution in reptiles, with special focus on those parameters across the PTME. We implement relaxed clock Bayesian inference analyses using total evidence dating and corrections for deep root attraction, establishing new and more precise estimates for the origin of the major lineages of diapsid reptiles. Our results indicate a considerable decrease in morphological disparity in the Early Triassic following PTME, but a quick recovery to pre-extinction levels by the Middle Triassic. We also find increasingly high rates of morphological evolution during the Early Triassic, supporting a model of fast adaptive radiation and occupation of new ecological niches following the aftermath of the Permain Mass extinction. Average rates subsequently stabilize during the Middle Triassic, but at relatively high levels, indicating the adaptive radiation event was still ongoing during the Middle Triassic, although some few lineages already reached more neutral levels of evolutionary rates. We also find that the origin of new and extreme body plans is marked by the highest rates of morphological evolution in the history of reptiles. In contrast, molecular rates of evolution present greater stability and more moderate values throughout most of reptile evolution. Our interpretations of the later are limited by the number of sampled loci, but lends support to previous studies indicating that great morphological changes, and possibly the origin of new body plans, are the result of the release of cryptic genetic variation instead of a large number of de novo mutations.

Grant Information: Alexander Agassiz Postdoctoral Fellowship [to TS]
ADDITIONAL FOSSILS REMAINS FROM THE HOMINOID BEARING LATE MIocene TAPPAR LOCALITY OF KUTCH, INDIA: IMPLICATION ON PALEOENVIRONMENT

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The Tappar locality of Late Miocene, Kutch, India is well known for its fossil mammal remains. However, the microfossils are very rare in the area. During the year 2018-2019 field work, various invertebrates, microflora and microfauna were recovered from the Tappar section of Chhasra Formation. We here report a list of invertebrate and microvertebrate fossils such as gastropods (Viviparus indet.), bivalves (Lamelildens indet), chorophytes (Chara globularis cf. aspera, C. globularis cf. globularis, C. sp. indet. and Nitetopsis (Tectocharus) meurini), teleost fish (cyprinids, bagrids, claridids, silurids and channids), chondrichthytes (Dasyatis rugosa, Dasyatis probsti, Himantura sp. and Pristis sp.) and small colubrine snake (Chotaophis padhriensis). The occurrence of fossil mollusces, chorophytes, teleost fish, chondrichthytes and colubrine snake from the late Miocene deposit of Tappar, Chhasra Formation, Kutch, Gujarat suggests the presence of fresh to slightly brackish water environment under tropical to temperate humid conditions during the Late Miocene (~11-10 Ma). This is also corroborated by a rich marine and reptilian fauna comprising elephants, rhinos, giraffids, equids, suids, crocodiles and turtles found associated with the present species at Tappar.

Grant Information:
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TROPHIC MORPHOLOGY REVEALS THE ECOLOGICAL DYNAMICS OF EARLY MESOZOIC HERBIVORES.

SURESH, Singh A., University of Bristol, Bristol, United Kingdom.

Terrestrial ecosystems underwent significant remodelling during the Late Triassic via faunal and floral turnovers that established many of the structural elements found in modern ecosystems. Paleozoic ‘holdovers’ such as the procolophonid parareptiles and dicyonodont therapsids were superseded by new archosauriform and mammalian clades. Recent stratigraphic revision has highlighted the potential role of the Campanian Pluvial Event (CPE) in spurring this turnover, focusing attention on the environmental changes and functional diversity of Late Triassic ecosystems. In order to investigate the impact of this event I chart the evolution of key herbivorous tetrapods groups through the Triassic and Early Jurassic Herbivores acutely reflect their functional diversity of Late Triassic ecosystems. In order to investigate the impact of this event I chart the evolution of key herbivorous tetrapods groups through the Triassic and Early Jurassic Herbivores acutely reflect their functional diversity of Late Triassic ecosystems. We assess the impacts of ecological and environmental dynamics through this interval. My results show a strong relationship between mandibular form and function within terrestrial herbivores. The clear morpho-functional concurrence allows me to dissect the morpho-functional variation of Triassic herbivores, and identify their different dietary strategies. Multivariate statistical analyses reveal significant differences in jaw morphology that suggest niche partitioning within the herbivore guild. Furthermore, morphospace and functional space occupation through time illustrates how divergent feeding ecologies may have acted in concert with the environmental changes in the Late Triassic to drive faunal evolution and the decline of key clades such as the dicynodonts and gomphodont cynodonts, and even the success of the archosaurs, particularly dinosaurs through the Triassic-Jurassic boundary. This pattern of niche partitioning and extinction selectivity that suggests intrinsic dissimilarities promoted differential survival, influencing but not driving the Triassic faunal transformation.

FOSSILS WITH FEATHERS AND PHILOSOPHY OF SCIENCE

SMITH, Holly E., Griffith University, Brisbane, Australia; PRICE, Gilbert, University of Queensland, Brisbane, Australia; RIZAL, Yan, Institut Teknologi Bandung, Bandung, Indonesia; ZAIM, Jahdi, Institut Teknologi Bandung, Bandung, Indonesia; PUSPANINGRUM, Mika, Institut Teknologi Bandung, Bandung, Indonesia; ASWAN, -, Institut Teknologi Bandung, Bandung, Indonesia; TRIHASCARYO, Agus, Institut Teknologi Bandung, Bandung, Indonesia; STEWART, Mathew, University of New South Wales, Sydney, Australia; LOUVYS, Julien, Griffith University, Brisbane, Australia.

Our study highlights the potential for analyses of breccia deposits in anthropological and paleontological studies in the caves of Southeast Asia in the future. Furthermore, our spatial distribution data uncovers evidence of multiple taphonomic agents that could offer a contemporary method of analysis in complex depositional cave environments that has removed all other indication of this activity. We present a taphonomic analysis of fossil material excavated from Ngalau Gupin, a cave located approximately 27.5 km southeast of the village of Sawahlunto in the Padang Highlands of western Sumatra, Indonesia. Extraction of fossils took place from two discrete cemented breccias, NG-A and NG-B, as well as from the unconsolidated cave floor. The cave breccia found in the cave preserved numerous fossil bones and teeth cemented on the cave walls (NISP ≈ 931). The dense nature of the breccia in Ngalau Gupin has preserved tooth crowns of tiny (≈1kg) to very large (≈180kg) species characteristic of the Late Pleistocene, including Panthera tigris, Panthera onca, Hystrix cristata and Ursus beringianus. In total, 21 species were identified, with over 1400 fossils catalogued in total. Tomographic imaging is used as a macro-taphonomic approach to determine the alteration processes of the vertebrate bearing breccia deposits from Gnalau Gupin during burial or post-deposition. One block sample was taken from both site NG-A and NG-B and these consolidated samples have been scanned in a neutron imaging station. Examination of the neutron scan images with evidence from the faunal analysis indicates that the vertebrate-bearing breccias are heavily altered from their original composition by multiple taphonomic agents. This evidence is critical in evaluating the paleoenvironment and the agents responsible for site formation events. This study highlights the potential of tomographic imaging of incorporated fossils...
and clasts within a cave breccia matrix to interpret taphonomic characteristics and infer the paleolatitudinal taphonomic history of incorporated faunal assemblages. These data could strengthen our understanding of the ancient rainforest migrations and occupation by hominids and associated paleoфаuna.

Technical Session I (Wednesday, October 9, 2019, 9:15 AM)

ENDOCRANIAL MORPHOLOGY AND ENCEPHALIZATION IN THE PROTOCETID CETACEAN GEORGIACETUS VOGTLENSIS

SMITH, Kathryn, Georgia Southern University, Statesboro, GA, United States of America; GEISLER, Jonathan, NYIT College of Osteopathic Medicine, Old Westbury, NY, United States of America; PATEL, Darshini, NYIT College of Osteopathic Medicine, Old Westbury, NY, United States of America

Endocranial morphology provides insight into the biology and behavior of extinct vertebrates. Previous studies have documented drastic changes to the endocranial region of cetaceans, including an increase in encephalization and a reduction or loss of the olfactory tract. Here we investigate this region in the protocetid archaeocete Georgiacetus vogtlensis (Mammalia: Cetacea) to provide insight into the evolution of archaeocetes. A digital endocard of the Georgiacetus holotype (GSM 350) was created using computed tomography. The endocard does not preserve subtleties of its external surface, but its overall shape reflects the shape of adnexia, including a posterior rete mirabile. The presence of a rete mirabile is suggested by the fact that the posterior cranial fossa is much wider and dorsoventrally taller than the anterior cranial fossa, whereas in extant cetaceans either smaller or subequal to the cerebral hemispheres. There is no trace of a fals cerebi; instead, a comparable position is marked by a narrow and tall cast of the dorsal sagital sinus. Posterior to this sinus is a triangular depression for a median tentorial projection, the only clear demarcation between the middle and posterior cranial fossae. Posterior to this depression the cast of the rete mirabile forms the highest point of the endocard, as in basoalosaurids but unlike in Indocetus and Remingtonocetus. A cross section through the anterior of the endocard is in shape, with a median dorsal section corresponding to the olfactory tract and bilateral ventral portions to neurovascular structures. This portion of the endocard is quite large and tubular, as in basoalosaurids but unlike the narrow morphology seen in Remingtonocetus.

The encephalization quotient (EQ) of Georgiacetus was calculated using the equation EQ = brain mass/0.12*body mass 0.67, a brain mass of 451 g (endocardal volume less retial volume, converted to mass) and a body mass of 672 kg (calculated using a regression equation from a previous study that predicts body mass based on skeletal length for modern cetaceans). The resulting EQ of 0.47 is subject to some uncertainty, but is higher than reported for Dalanistes, slightly lower than reported for most basoalosaur archaeocetes, and substantially lower than reported for nearly all modern cetaceans. This supports previous studies that show increased encephalization, a common characteristic of modern cetaceans, did not evolve in archaeocetes.

Technical Session V (Wednesday, October 9, 2019, 3:45 PM)

PHYLOGENETIC RELATIONSHIPS OF SULIDAE (AVES: SULIFORMES) INFERRED FROM EXTERNAL MORPHOLOGICAL CHARACTERS AND CONGRUENCE BETWEEN MORPHOLOGICAL AND MOLECULAR Datasets

SMITH, Nathan, Natural History Museum of Los Angeles County, Los Angeles, CA, United States of America; WATKINS, Jalesa, Howard University, Washington, DC, United States of America; JAY, Judith, Howard University, Washington, DC, United States of America

Sulidae are a group of seabirds comprised of ten species of gannets and boobies. They were historically classified within the polyphyletic avian order Pelecaniformes, a group notable for long-standing conflicts between molecular and morphological estimates of relationships. Diverse phylogenetic datasets focused on solid relationships exist for DNA, osteological, and behavioral characters. However, no external morphological (e.g., plumage traits) dataset exists, and no attempt has been made to analyze the varying levels of congruence of these disparate datasets. We present a new dataset of 24 external morphological characters collected for Sulidae and outgroups. The dataset was analyzed using maximum parsimony to infer evolutionary relationships within Sulidae. Our results exhibit some congruence with previous analyses (e.g., monophyly of Sulidae, Morus, and a Sulidae monophly and Sulavariagae clade), but differ primarily in: 1) failing to recover Sulavariagae clade; and 2) the position of Papaflu. The latter result confirms that independent forms of character data (nuclear genes, mitochondrial genes, osteology, external morphology) all differ in the placement of this enigmatic species. Trees inferred from osteological, behavioral, and external morphological datasets show variable congruence and conflict with the molecular topology, cautioning against simplistic arguments regarding “morphology vs. morphology” debates in phylogenetics. Additionally, statistical tests reveal that osteological, behavioral, and external morphological datasets all possess significant phylogenetic signal on the molecular tree, and also do not differ significantly from each other in measures of homoplasy or retained synapomorphy. These results lay the groundwork for more rigorous total evidence analyses of sulid phylogeny incorporating disparate data, and also suggest that the relationships of extinct sulids can be robustly resolved within such a framework. Future work requires a two-fold approach of rigorously assessing hypotheses of primary homology in avian morphological characters, and testing hypotheses of convergence using modern phylogenetic comparative methods.

Grant Information:
NSF OPP-1341475 (NDS); NSF DEB-0808250 (NDS)

Technical Session VI (Thursday, October 10, 2019, 11:00 AM)

WEEKLY-SCALE OXYGEN ISOTOPE MEASUREMENTS IN PRIMATE TEETH REVEAL ANCIENT ENVIRONMENTAL VARIATION

SMITH, Tanya M., Griffith University, Nathan, Australia; GREEN, Daniel R., Forsyth Institute, Cambridge, MA, United States of America; WILLIAMS, Ian S., The Australian National University, Canberra, Australia

Oxygen isotopes in tooth enamel vary with temperature, precipitation, and evaporation cycles during an organism’s development. Using modern phylogenetic comparative methods, we analyzed teeth from ancient hominins and other primates sampled sequentially along the enamel-dentine junction on a spatial scale corresponding to a near-weekly timescale using secondary-ion mass spectrometry. Standardized δ18O values were related to temporal records of formation over 3-4 years per tooth. Oxygen isotope values in wild-shot Bornean and Sumatran orangutans first molars ranged from 11.3 to 19.9 %, and 13.4 to 20.4 %, respectively. Concurrently forming left and right molars from the same fossil orangutan ranged from 15.4 to 20.1 % and 15.1 to 19.9 %, supporting the biogeic fidelity of this paleoclimate record. All teeth showed isotopic variation on a circumannual basis, particularly after the animals ceased feeding exclusively on mother’s milk.

Enamel is the most chemically resilient tissue in the body, and the recovery of seasonal environmental patterns from teeth. We demonstrate here and in other studies that isotope variation in fossilised mammalian tooth enamel formed over multiple years is substantial, even in equatorial regions. Future research on slow-growing primate teeth may help to establish conclusively whether environmental variation was a significant force in the evolution and dispersal of the human genus (Homo) and our own species 300,000 years ago.}

Grant Information:
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Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)

PALEOCENE AND EARLY EOCENE BIRD ASSEMBLAGES FROM THE SOUTHERN NORTH SEA BASIN

SMITH, Thierry, Institut Royal des Sciences Naturelles de Belgique, Brussels, Belgium; MAYER, Gerald, Forschungsinstitut Senckenberg, Frankfurt Main, Germany

Numerous bird bones from the Paleocene and early Eocene of the Belgian and Paris basins have been collected by amateur paleontologists. Four bones from the early-middle Selandian of Maret, Belgium, are among the earliest
Cenozoic avian remains from Europe and include the oldest temporally well constrained records of the Gastornithidae as well as tentative records of the paleognathous Lithornithidae and the Ratitornithiformes. Another assemblage from the middle Thanetian of Templepre, France contains multiple bones of the Lithornithidae as well as a record of the Pelagornithidae. Specimens from the latter Thanetian of Taxacourt-Prét Plîtes, France are tentatively assigned to the Ratitornithiformes and Leptosomiformes. An assemblage of 54 bones from the middle Ypresian of Egem, Belgium represents at least 20 species in more than 11 higher-level taxa. Well-identifiable specimens are assigned to the Odontopterygiformes, Galliformes, Mesoselornithidae, Apodiformes, Halcyornithidae, Leptosomiformes, and Coraciiformes. Further specimens are tentatively referred to the phaethontiform Prophaethontidae and to the Accipitriformes, Massiliairoturidae, and Alcediniformes.

These three-dimensionally preserved fossils provide new data on the osteology of taxa that are otherwise mainly known from compression fossils with crushed bones. They also further knowledge of the composition of early Paleogene avifaunas of the North Sea Basin. Paleocene avifaunas of Europe and North America are the result of early Cenozoic dispersal events. The well-represented small galliform species from Egem most closely resembles Argillegis aurorum, an ignored galliform species from the London Clay. The tentatively identified fossils of Accipitriformes and Alcediniformes would represent the earliest fossil records of these clades. The birds from Egem include few seabirds (Odontopterygiformes, cf. Prophaethontidae) and is dominated by terrestrial species (Galliformes, Mesoselornithidae). Arborial birds (Halcyornithidae, Leptosomiformes, cf. Alcediniformes, Coraciiformes) are less abundant and aerial insectivores (Apodiformes) very scarce, which either indicates a tropicomonic bias in the composition of the avifauna or particular paleoenvironmental characteristics of the nearshore habitats in that area of the southern North Sea Basin.

Grant Information:
Funded by Belgian Science Policy Office (project BR/121/3/PathFarAfrica).

Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM)

SMALL CARNIVORE COPROLITES FROM THE LATE TRIASSIC OF SOUTHERN BRAZIL: PALEOBIOLOGICAL IMPLICATIONS


A remarkable fauna is recorded in early Norian beds (ca. 225.42 ±0.37Ma) from the municipality of Faxinal do Soturno, State of Rio Grande do Sul, Brazil. This is mainly composed by small-sized vertebrates (maximum body length around 200-250 mm), such as probainognathian cynodonts, rhynchocephalians, non-rhynchocephalian lepidosauromorphs and archosauriforms. Only relatively large animal found there is the saurischian Guania barbarosa (ca. 2m). The fossils occur in massive sandy lenses interpreted as a fluvial/deltaic system. In this same level, more than 50 elliptical coprolites, resembling rodentian feces, were found. They exhibit a whitish color and range from 7 to 10mm long and 3 to 5mm in diameter. Eight isolated coprolites were analyzed chemically and by microscopy. The x-ray diffractionmetry indicated a high feldspar class, smectite and apatite with major pick, consistent with carnivore coprolite materials. Thin section analyses showed a massive coprofaible bearing sand (quartz) grains and bone remains. Micro-CT images were obtained from a sandy block with seven “in situ” coprolites. Inside each one, a dense amount of millimetric bone elements was revealed compound about 40-70% of the total volume. All bones are disarticulated. Some are complete, but the most part fragmented. Few signs of chemical corrosion (pits) are present. Among the identifiable elements are indeterminate long bones, ribs, phalanges, and parts of neural arches of the rhynchocephilian Cleurosaurus brasiliensis. Although it is difficult to determine if these coprolites unequivocally to a specific producer, their measurements are in accordance with the sizes of the aforementioned small tetrapods. The evidences point out to a strict carnivore producer with some ability of chewing bones and with fast digestion, which refers to more mammalian physiology than a reptilian one. The sand inside the coprolites is suggestive of soil ingestion during feeding to obtain nutrients, as commonly practiced by current forms of animals, or just accidental ingestion. Therefore, we defend the probainognathian clade as potential candidates. This is corroborated by their posteriorly Baculopterygii with a more effective occlusion, enabling chewing movements, and features suggestive of fossoriality, like a robust humerus and hypertrophied rodent-like lower incisors (e.g., Irajatherium, Rostrigrandia). This unprecedented Triassic record constitutes a rich ichnologic data source that contributes for a better understanding of the initial steps of the mammalian paleobiology.

Grant Information:
CNPq - 312387/2016-4 (MBS)

Technical Session XIII (Friday, October 11, 2019, 1:45 PM)

A SMALL DIAPSID FROM THE LOWER KEUPER OF GERMANY AND THE ORIGIN OF AQUATIC REPTILES

SORRAL, Gabriela, Staatliches Museum für Naturkunde Stuttgart, Stuttgart, Germany; SCHÖCH, Rainer, Staatliches Museum für Naturkunde Stuttgart, Stuttgart, Germany

The Middle Triassic was a time of major changes in terrestrial tetrapod faunas, but the fossil record of this interval is largely obscure. This is unfortunate, since many modern groups originated or diversified during this time. However, recent excavations in the upper Middle Triassic of Germany have revealed several new taxa, most of which are much smaller than those found in other tetrapod-bearing basins of similar age. Here, we report a new taxon from the Vellberg limestone quarry comprised of skull bones distinct from other diapsids from this locality. It is diagnosed by a long maxilla with a far posteriorly reaching tooth row, a long and stout ventral process of the postfrontal; exclusion of the postorbital from the lower temporal fenestra due to a contact between the anterocentral process of the squamosal and the dorsal process of the jugal; and a tall quadrato + quadratojugal complex. Some anatomical aspects of the new taxon (s. a. the “ventral cheek embayment”) resemble those of the ichthyopterygian Hupehsuchus, and Wumengosaurus, as well as in rhynchocephalians. Derived ichthyosaurs show the typical jugal-quadratojugal contact, but via an unusual dorsal contact between the two. The jugal–squamosal contact may thus represent a transitional stage to the anatomy observed in later ichthyosaurs, reinforcing the interpretation of the ‘ventral cheek embayment’ of basal ‘euryapsids’ as a ventrally open lower temporal fenestra. Thus, the new taxon has implications for the origin of secondarily aquatic groups, and therefore also paleobiogeographic significance. The appearance of placodontians has been traced to central Europe, but ichthyopterygians are believed to have originated in the Western Tethys, associated with the Germanic Basin. This new material emphasizes the importance of sampling small-bodied taxa in the understanding of reptile evolution.

Grant Information:
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Colbert Prize Poster Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)

UNUSUAL TOOTH REPLACEMENT IN A NEW CENOMANIAN IGUANODONTIAN FROM THE MUSSENTUCHIT MEMBER OF THE CEDAR MOUNTAIN FORMATION

SOKOLSKY, Tymofi, Duke University, Durham, NC, United States of America; ZANNO, Lindsay, North Carolina Museum of Natural Sciences, Raleigh, NC, United States of America; KOSCH, Jens C., North Carolina Museum of Natural Sciences, Raleigh, NC, United States of America

A partial skeleton including both dentaries and multiple isolated teeth of an early diverging iguanodontian (NCSM 29373) was excavated from the Cenomanian-aged Mussentuchit Member of the Cedar Mountain Formation in Sanpete County, Utah during the 2014-2016 field seasons. Due to the presence of jaw sections with unerupted teeth, we were able to calculate tooth replacement rates of NCSM 29373 by counting incremental von Ebner lines of enamel. Moreover, we were able to determine the number of teeth that were preserved – 17 teeth (n=11, range = 13-42.3 mm). A reconstructed crown height of 6719 µm, yields an estimated tooth formation time of 395 days. Enamel thickness was determined to be greatest at the central ridge on the labial side of the tooth – 159 µm compared to 88 µm in between the ridges.
Micro CT scan of the dentary revealed two teeth in each alveolus — one functional tooth and one replacement tooth. Using this data we determined crown height in two successive teeth (7.07 mm for the functional tooth and 3.53 mm for the replacement tooth) and derived formation time — specifically, 416 days for the functional tooth and 208 days for the replacement tooth and an estimated tooth replacement rate of 208 days.

Tooth replacement rate in the Mussentuchit iguanodontian (NCSM 29373) is 2-4 times slower than calculated for hadrosaurs with specialized tooth batteries (e.g., Edmontosaurus and Pasaurolophus average 50 and 81 days respectively). In fact, although slightly faster, tooth replacement rate in NCSM 29373 is most comparable to that of theropods, perhaps reflecting a plesiomorphic condition — a slower rate is expected for early-diverging ornithopods not yet exhibiting a sophisticated tooth battery. Alternatively slower tooth formation time and replacement rates may be due to specialization of NCSM 29373; further data among non-hadrosaurian ornithopods is necessary to test amongst these competing hypotheses.

Regular Poster Session III (Friday, October 11, 2019, 4:15 - 6:15 PM)

**RECONSTRUCTING COMPLEX PATTERNS OF ENAMEL ON A TOOTH WITH COMPUTATIONAL SIMULATIONS**

SOVA, Susanna, University Helsinki, Helsinki, Finland; HÄKKINEN, Teemu, University Helsinki, Helsinki, Finland; MORTITA, Wataru, University Helsinki, Helsinki, Finland; JERNVALL, Jukka, University Helsinki, Helsinki, Finland

Teeth of most mammals are covered by a layer of highly mineralized enamel that cannot be remodelled or repaired. Several mammalian lineages have evolved thick enamel, associated with diverse dietary adaptations. Consequently, differences in enamel thickness among species have been used to examine functional properties of teeth. The thickness of the enamel layer, however, is rarely completely uniform over the crown. Since the enamel surface is not a simple extrapolation of the dentine surface, it is difficult to reconstruct the surface based on the dentine. Variable enamel thickness implies that the process of enamel matrix secretion itself plays a role in dietary adaptations. Nevertheless, it remains to be explained how the distribution of enamel on the tooth crown is developmentally regulated. Here we use molaris of extant suids (Sus domesticus, Phacochoerus africanus) and primates (Homo sapiens, Gorilla gorilla, Pongo pygmaeus) with a computational model to explore which kind of mechanisms could underlie the complex patterns of enamel distribution. Starting from tomography-imaged teeth from which enamel has been digitally removed, enamel secretion is computationally simulated. We show how using a diffusion-limited secretion of enamel matrix, it is possible to reconstruct the enamel distribution on the tooth. Moreover, diffusion limited secretion of the enamel matrix can substantially increase the complexity of the tooth surface. These simulations provide a simple principle that accounts for the complex patterns of enamel distribution found in many taxa, and suggest a framework to classify teeth and taxa based on the mode of enamel formation.

Regular Poster Session I (Wednesday, October 9, 2019, 4:15 - 6:15 PM)

**A LARGE PTEROSAUR HUMERUS FROM BONE CABIN QUARRY, MORRISON FORMATION, COLORADO**

SPRAGUE, Michael, Loma Linda University, Loma Linda, CA, United States of America; MCLAIN, Matthew A., The Master's University, Santa Clarita, CA, United States of America

Bone Cabin Quarry is a historic Morrison Formation quarry in southeastern Wyoming. Here we describe a large pterosaur humerus from this locality (EDF-SM 2017.02.003) housed at the Newport Museum in Eccles Dinosaur Park. Its stratigraphic position places it among the oldest pterosaurs in the Morrison Formation. The bone is three-dimensionally preserved, although slightly crushed, and is the largest definitively Jurassic pterosaur humerus recorded in the literature. Proximodistal length is 110.5 mm, and the diaphysis measures 16 mm at its median point. The deltopectoral crest is tongue-shaped with a semi-rounded distal end and is inclined proximally. The distal half of the humerus is bowed anteriorly. The capitulum is more expanded than the entepicondyle, and the radial condyle is visible as an elongated lozenge-shaped that angles diagonally toward the ulnar condyle. In order to determine the wingspan of the pterosaur that possessed this humerus, wingspans from various rhamphorhynchid pterosaurs were graphed using a previously published dataset. Deriving a regression equation from the data and substituting in the proximodistal length yields a result of 2067.6 ± 169.7 mm. Previously, the largest definitively Jurassic humerus in the literature measured 100 mm and had an estimated wingspan of 1.6-3.2 m, although there is a 112 mm long humerus from Thailand (PRC 64) that may be from an uppermost Jurassic deposit. Most rhamphorhynchid humeri to which this specimen could be compared are not three-dimensionally preserved, so it is difficult to assign it to a specific clade within Rhamphorhynchidae. Nevertheless, we could understand the most morphologically similar to those seen in Dorygnathus and to PRC 64, the putatively Jurassic humerus from Thailand that was considered an azhdarchoid but we interpret to be a rhamphorhynchid. The Bone Cabin humerus differs from Dorygnathus humerus in size and in the morphology of the distal condyles. It is similar in size to PRC 64, although the distal condyles in PRC 64 are not well-preserved. Also found in Bone Cabin Quarry was the holotype rostrum of Harpactognathus gentryii, a rhamphorhynchid. By extrapolating total skull length, the wingspan was estimated to be approximately 2.5 m. Given the wingspan estimate for the humerus is similar, it is possible that the two bones belong to the same species. Regardless, the discovery of this Bone Cabin humerus provides more evidence for surprisingly large pterosaurs (~2-2.5 m wingspans) in the Jurassic of north Nicaragua.
Grant Information: Expenses were funded by the Department of Earth and Biological Sciences at Loma Linda University.

Colbert Prize Poster Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)

CONSTRAINTS AND ADAPTATIONS IN CROCODILIAN SKULL FORM AND FUNCTION

SRINIVAS, Ananth, University of Pennsylvania, Philadelphia, PA, United States of America; RAYFIELD, Emily J., University of Bristol, Bristol, United Kingdom; TAVARES, Sandra A., Museu de Paleontologia, Sao Paulo, Brazil; CUNNINGHAM, John, University of Bristol, Bristol, United Kingdom

Crocodilians, one of only two living groups of archosaurs, display a diverse range of skull morphologies. A classic hypothesis states that crocodilian skull shape is responsive to selective feeding strategy; yet extant crocodilians possess platybral (broad and flat) snouts, thought to be sub-optimal for feeding due to the conflicting demands of feeding optimization and hydrodynamically constrained. In contrast, numerous Mesozoic crocodilians possessed oreinostral (dome-shaped) skulls. Some of these forms were terrestrial and hence free from the aforementioned constraints. This study aims to review the role of functional constraints that determine skull shape in this group of crocodilians and seeks to assess the differences in the feeding mechanics between the terrestrial extinct taxa and the semi-aquatic extant taxa. This was carried out using beam analysis and finite element analysis (FEA) for evaluating resisting force as lower stresses were observed under various biting scenarios. Conversely, bite forces are independent of rostral shape and instead scale positively with body size. The oreinostral taxa, however, show increased mechanical advantages compared to their platybral counterparts, due to the differences in the musculoskeletal architecture. Overall, fossil taxa with oreinostral morphologies show skull structures that are better optimized for feeding in the absence of hydrodynamic constraints. These observations are expected to serve as models to explore further the biomechanics of other tetrapods with homologous morphologies.

Regular Poster Session III (Friday, October 11, 2019, 4:15 - 6:15 PM)

CRANIOFACIAL ONTOGENY IN PACHYCEPHALOSAURUS WYOMINGENSIS

STEFANSKI, Douglas J., Carthage College, Kenosha, WI, United States of America

Pachycephalosaurus wyomingensis was the largest of the pachycephalosaurid dinosaurs. It lived in the Maastrichtian age of the late Cretaceous period in North America, and its fossils have been found in Wyoming, South Dakota, and Montana. The goal of this study was to recover the ontogeny of the craniofacial skeleton of P. wyomingensis through quantitative clastic analysis. A previous hypothesis of ontogeny divides the growth series of P. wyomingensis into juvenile (2 specimens), subadult (10 specimens), and adult (7 specimens), which is a low resolution hypothesis because multiple specimens are included in each group. An clastic analysis provides a high resolution analysis that has the potential to recover the relative maturity of each specimen relative to each other. A hypothetical embryo was used as an outgroup. Nine cranial characters were independently coded, including four binary growth characters and five multistate growth characters. An exhaustive search recovered five trees, with a CI of 1.00, an HI of 0.00, an RI of 1.00, an RC of 1.00, and a tree length of 14 steps. The growth stages (based on one of the 5 most parsimonious trees) are defined by: Stage 1 (UCMP 130049) is not supported by an optimal character, Stage 2 (UCMP 134979, TCN 2004.17.1), a frontoparietal (fp) dome zone 2 that is reduced, a fp dome zone 3 that is moderately thinning; Stage 3, a dorsal temporal fenestra that is closed, a fp dome that is significantly inflated, a fp dome that is moderately long. There are two groups beyond this stage; Group 1 (fully domed Pachycephalosaurus) and Group 2 (Stygimorph). Group 1, Stage 1 (UCMP 556078), a middle anterior node that is absent; Stage 2 (VRD 13), a horn/node profile that is blunt; Stage 3 (AMNH FARB 1696), a fp dome length that is long. Group 2, Stage 1 (MOR 453), a reversal in fp dome zone 2 from reduced to moderate; Stage 2 (UCMP 128383, MPM 8111), a reversal in the fp dome inflation from significant to moderate inflation. Growth rank data are normally distributed under a Shapiro-Wilk test (p = 0.933). The splitting in the tree is evidence of sexual dimorphism in P. wyomingensis. It is unclear which group represents which sex.

Technical Session XI (Friday, October 11, 2019, 9:15 AM)

LATE HOLOCENE FAUNAL DYNAMICS IN A NORTHERN ROCKY MOUNTAIN FOREST COMMUNITY

STEGNER, M. Allison, Stanford Univ, Stanford, CA, United States of America; HADLY, Elizabeth A., Stanford Univ, Stanford, CA, United States of America

Anticipating how species and ecosystems will respond to climate change is critically important to conservation of biodiversity and functioning ecosystem processes. Identifying how species in a community have responded in the past can be accomplished by evaluating the fossil record, and by comparing paleoecological trends to modern abundance and diversity. Detailed paleoecological records from Quaternary deposits have long been used to characterize century-to-millennial scales of ecological dynamics, but few Quaternary localities have sampled the small mammal community of forested ecosystems. Here, we document changes in small mammal diversity in Waterfall Community, a fossil packrat midden assemblage from northeastern Yellowstone National Park. Material is analyzed using a product of packrats (Neotoma cinerea) concentrating carnivore scats and pellets of avian predators. AMS radiocarbon dates on 8 bone and 13 charcoal samples suggest that the site spans ~4500-200 calendar YBP, and so this site contributes to our understanding of pre-industrial variation in the Yellowstone region by providing faunal data for a period of recent climate change, most notably the Medieval Climatic Anomaly.

We trace relative abundance and community evenness of 28 small mammal taxa from the genera Mustela, Erinithlon, Ochotona, Lepus, Marmota, Tamiasciurus, Spermophilus, Phascocarys, Microtus, Sylviagius, Zapus, Sorex, Thomomys, Neotoma, Glaucomys, Tamias, Peromyscus, and Ctenomys. We find no significant correlations among abundances of different taxa, indicating that species are responding individually to their environment. Using Probability of Intraspecific Encounter (PIE), we found no significant changes in evenness through time. However, Constrained Hierarchical Cluster Analysis (CONISS) reveals periods of relatively stable taxonomic composition from ~4500-2000 calendar YBP and ~2000-200 calendar YBP, followed by repeated, rapid (on the scale of 100 years or less) compositional reorganization from ~1800-200 calendar YBP. Preliminary data comparing the proportion of nocturnal versus diurnal taxa suggests that vectors of bone accumulation (i.e., which predators are responsible for the assemblage) have changed little over the course of the last ~4500 years.

Technical Session XX (Saturday, October 12, 2019, 3:30 PM)

GEOMETRIC MORPHOMETRIC AND FINITE ELEMENT ANALYSIS OF THE MEKOSUCHINE CROCODILE FORELIMB AS AN ASSESSMENT OF LOCOMOTION

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The focus of evolutionary biomechanics is to relate form to evolutionary function in the context of physical constraint. A morphological shift in the fossil record would therefore indicate a concomitant shift in ecological condition. Mekosuchine crocodiles (Crocodyliidae, Mekosuchinae) of Oligo-Miocene Australia display departures from the typical eusuchian body-plan both in the cranium and postcranium. Results from previous qualitative studies suggest these crocodiles had a more terrestrial habitus compared with modern crocodylians, yet the full capacity of mekosuchine locomotion remains to be tested. We apply a quantitative geometric approach, using both geometric morphometric and finite element methods, to examine the unusual morphology of the mekosuchine humerus observed in specimens available from Queensland and the Northern Territory and estimate the locomotory stresses engendered by it. The results indicate differences in the geometry of the diaphysis between modern freshwater crocodiles and mekosuchines along with different patterns of structural stresses between models that simulate sprawling and high-walk gaits. Our results lend quantitative support to the terrestrial habitus hypothesis and suggest behavioral adaptations for burrowing in late Plio-Pleistocene mekosuchines.

Funded by Australian Research Council Discovery Grant DE150100862 to L.A.B. Wilson and additional ARC grants DP170101420 and DP180100792 to M. Archer and S. Hand.
LATE Oligocene Macroscelideans from the Nsungwe Formation, Rukwa Rift Basin, Tanzania

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Among the least sampled intervals in vertebrate evolutionary history is the late Oligocene of continental Africa. The Nsungwe Formation in the Rukwa Rift Basin of Tanzania has revealed a rich faunal assemblage with key first evidence for the divergence of cercopithecoids and hominoids discovered alongside late-surviving parapithecid primates. Age constraint for the formation leverages high-precision U-Pb and Ar/Ar geochronology of intercalated volcanic tuffs. Multiple localities sample differing depositional environments and preserve a range of vertebrate fossils including articulated anuran, reptile, snake, turtle and fish remains, as well as a diversity of invertebrate fossils. Non-primate mammals include numerous rodents, as well as evidence of hyracooids, anthracotheres and a hyaenodont. Here we report on novel macroscelideans recovered from localities in the Songwe Member of the Nsungwe Formation, documenting a glimpse into African mammalian evolutionary history at the Paleogene-Neogene boundary.

Grant Information:
National Geographic (CRE), Leakey Foundation, Ohio U HCOM, National Science Foundation EAR 0617561; EAR/IF 0933619; BCS 1127164; BCS-1313679; EAR-1349825; BCS-1638796.

Technical Session II (Wednesday, October 9, 2019, 8:30 AM)
PALEOENVIRONMENTAL ASSOCIATIONS AND VERTEBRATE ICHNOLOGY OF A DIVERSE, MULTI-LAYERED, DINOSAUR TRACK ASSEMBLAGE FROM THE UPPER CRETACEOUS CANTWELL FORMATION (MAASTRICHTIAN), DENALI NATIONAL PARK AND PRESERVE, ALASKA

STEWARD, Dustin G., University of Alaska Museum, Fairbanks, AK, United States of America; ERICKSON, Gregory M., Florida State University, Tallahassee, FL, United States of America; CAPPs, Denny, Denali National Park and Preserve, Denali Park, AK, United States of America; BENOWITZ, Jeffery, University of Alaska Geophysical Institute, Fairbanks, AK, United States of America; MAY, Kevin C., University of Alaska Museum, Fairbanks, AK, United States of America; MCCARTHY, Paul J., University of Alaska, Fairbanks, AK, United States of America

Denali National Park and Preserve (DENA) in south-central Alaska has recently been recognized as a major high latitude dinosaur track-bearing locality. An assemblage of exceptionally diverse and well-preserved tracks is preserved in the Upper Cretaceous Cantwell Formation in DENA. However, ichnological and paleoenvironmental studies are still in their infancy, due in part to the remote nature of the mountainous exposures and substantial tectonic deformation that limits our understanding of the stratigraphic relationships within the formation. Here we present data on the largest known single in situ track assemblage currently known in DENA and all of Alaska, a football-sized outcrop of nearly-vertically inclined, fossiliferous rock exposed as a series of cascading cliffs. This site, known as the Coliseum, is composed of 65+ meters of vertical section, with laterally extensive mudstones, fine- to medium-grained sandstones, carbonate-siliciclastics, and bentonite. Facies analysis of the fossiliferous horizons reveal organically rich, repetitive fining upward successions of varying thickness commonly exhibiting small asymmetric ripples suggesting the tracks were formed subaerially on top of shallow water crevasse splays within an alluvial floodplain. U-Pb dating of zircons collected from a bentonite at the site return an age of 69.4±0.9 Ma, adding important new data to understanding the temporal constraints of the formation and their stratigraphic relationships to other dinosaur sites in Alaska, including the penecontemporaneous Prince Creek Formation in northern Alaska. Trace fossils at the Coliseum include true tracks, undertracks, natural casts, and trackways that vary in their preservation from eroded, trampled surfaces to skin impressions. The tracks were documented via handheld and UAV-assisted photogrammetry, enabling a large-scale 3-dimensional mapping of the Coliseum, including inaccessible surfaces. Large-bodied ornithopod tracks (Hadrosaurapod) dominate the assemblage, along with those of ceratopsians and a variety of non-avian theropods (including probable tyrannosaurid) and avian tracks are also preserved. The extensive trace fossil record of the Cantwell Formation provides important complimentary data to the body fossil record preserved in the Prince Creek Formation, allowing better understanding of the taxonomic composition and paleoecology of Late Cretaceous Arctic ecosystems.

Grant Information:
This work was funded by the National Park Service through an award to P. Druckenmiller

Technical Session V (Wednesday, October 9, 2019, 3:30 PM)
AVIAN EVOLUTION NEAR THE TIBETAN PLATEAU AND EVIDENCE FOR CENTRAL ASIAN ARIDITY IN THE LATE MIocene BASED ON THE FIRST FOSSIL SKELETON OF A SANDGROUSE (AVES: PTEROLCIDAE) FROM THE LINXIA BASIN IN WESTERN CHINA

STIDHAM, Thomas, Institute of Vertebrate Paleontology & Paleoanthropology, Beijing, China; LI, Zhileng, Institute of Vertebrate Paleontology & Paleoanthropology, Beijing, China

Adding to the rapidly growing avian fauna of vultures, falcons, peacocks, and ostrich from the Lixiu Formation (7.25-11.1 Ma), is a partial skeleton of a sandgrouse (Columbiformes) that is the most complete fossil of the group known, the oldest record of the group in Asia, and fills a significant temporal gap in their Neogene history. The specimen includes articulated and associated elements of the wing, shoulder girdle, vertebrae, and hind limb. The skeleton preserves a notarium of four fused vertebrae that is present also in pteroclids and columbids. The fossil’s coracoids have short shafts unlike that of stem pteroclids and columbids. The dorsal supracondylar tubercle on the humerus is elongate and differs from that of columbids. The radiale has a much less distinct groove for m. ulnometacarpalis ventralis than the condition in the sandgrouse genus Syrrhaptes. The furcula has a unique elongate (caudodorsally directed) articulation with the coracoid that may be an autapomorphy of this extinct species. Despite occurring within the extent geographic range of the Asian endemic Syrrhaptes, it appears that the fossil is a member of the crown pteroclid clade, and also outside of crown Syrrhaptes. This pteroclid skeleton was found associated with the foot of an eigornithine groud and mammalian remains, and the majority of the sandgrouse skeleton is adjacent to and in contact with a horned bovid skull roof. The mixture of articulated, semiccomplete individuals, and broken, unassociated vertebrate remains in otherwise structureless fine-grained sediments parallels that seen at other localities in the Lixiu Formation. That taphonomy potentially suggests flood plain deposition during a flash flood event (possibly related to the seasonal Asian monsoon).

Males of extant sandgrouse are known for their unusual use of modified breast feathers for absorbing water from permanent water bodies and transporting it long distances to supply their young. Extant and fossil sandgrouse are known from arid habitats across Eurasia and Africa. The interpretation of the Linxia Basin deposits at the northeastern edge of the Qinghai-Tibetan Plateau has been as an arid savannah habitat occupied by a diverse Hesperornis fauna. The occurrence of a sandgrouse within this environmental setting reinforces the hypothesis of drying and increased aridity in Central Asia associated coincidently with the rise of the plateau. Even though fossil fish are unknown in the formation, the discovery of this sandgrouse points to the past presence of permanent water bodies in the area.

Grant Information:
National Natural Science Foundation of China #NSFC4177203

Education and Outreach Poster Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)
PRACTICES FOR NATURAL HISTORY MUSEUM PROGRAMS TO CLOSE THE DISABILITY ENGAGEMENT GAP FOR PEOPLE WITH THE AUTISM SPECTRUM DISORDER

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Many of the first contacts with paleontology by the public are with science presented in a museum setting. However, crowded, loud, and sensory dense natural history museums and exhibits can create an engagement gap with respect to people with the Autism Spectrum Disorder (ASD) because they are less likely to visit a museum or visit less frequently. This gap can be bridged by both easily implemented and more costly modifications that will create a warm, comfortable, and welcoming environment for the ASD population. Even the simplest changes to exhibit and other public spaces, such as reducing light levels, reducing or eliminating sounds, and restricting crowd sizes, all contribute to the creation of a beneficial sensory environment. Avoidance of excessive amounts of bright white and red colors in public areas (and in staff clothing) can help to reduce their triggering effects. Programs should provide
sensory rooms or spaces that serve as a quiet, calm retreat. One key component is providing adequate information prior to any visit, including a sensory map of the museum (along with well-marked access to toilets and sensory room), times when the museum is not crowded, and a social story about visiting the museum and its exhibits (highlighting any potentially stressful parts of the exhibits or events). Optimal programs for those with ASD can provide exclusive (at least partial) museum access by opening early or later than normal hours (an hour or two) for a limited number of pre-registered families with members with ASD. The exclusivity of an autism event allows families to be comfortable in an understanding environment free from judgment, and free to explore at their own pace, participating in the direction of their interests. In addition, (weighted) sensory backpacks can be provided to visiting families (when requested), and they should include a variety of items such as noise-canceling headphones, sensory spinners, and other items to relieve stress. Do not set low expectations for visitors with ASD. Only adjust the setting and the approach, not the scientific content or activities. People with ASD are active contributors, not just observers to the exhibits. Make programs for ASD (and other non-physical disabilities) integral to education programs with associated training across the staff, and thus not reliant on a single person or position. While outside funding may help initiate ASD programs in a museum, they should not be considered as separate from the normal education budget and operations of a museum.

Technical Session IV (Wednesday, October 9, 2019, 3:00 PM)

IMMUNOHISTOCHEMICAL INSIGHTS INTO DISTRIBUTION AND OSTEOLOGICAL CORRELATES OF PERIODONTAL LIGAMENT INNERVATION IN DIDEPHIS VIRGINIANA

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The periodontal ligament (PDL) around tooth roots is a multimodal sensory system in mammals. It anchors the teeth to the alveolar sockets by a network of unmineralized collagen fibers, and nerve fibers in PDL form a sensory complex that transduces and integrates sensations of pressure, vibration, and pain from the teeth to the brain. New modern studies of the evolution of the PDL. Metatherians such as D. virginiensis are sistergroup to eutherians and can be phylogenetically informative for interpreting the ancestral characters of basal mammals. We have identified and mapped individual nerve locations and types around the roots of lower m1 of Didephys using immunofluorescence. Blood vessels, nerves, as well as glial and glial-related cells surrounding neurons were immunolabeled with S100, two neurofilament motor proteins (SMI 312 and NF-M), and protein gene product 9.5 (PGP 9.5). The labeled structures were imaged with a confocal microscope. To quantify the orientation and organization of PDL collagen sections were stained with Picrosirius Red (PSR) and imaged with circular polarizing microscopy. Collagen orientations were measured using direction image analysis with Orientioal package in Fiji.

RESULTS: SMI 312 was found to be the most effective neuronal marker. S-100, NF-M, and SMI 312 showed neurons running dorsoventrally in neurovascular bundles parallel to both the alveolar socket and tooth root. Nerves enter the PDL both through the root apex PDL space and laterally through the alveolar bone. Nerves are more numerous and diffuse within the PDL at the apex of the root. PSR revealed that the collagen fibers attaching to the lower two thirds of the root radiate upwards and outwards from the tooth root to the alveolus. In the upper one third, close to the crown, collagen fibers radiate both upwards and downwards as they run from the root to the alveolus. We identified several possible osteological correlates of PDL innervation, which can be mapped to basal mammalianiforms in early mammalian evolution:

1. The inter-radicular PDL: blood vessels enter the inter-radicular PDL, all along its length, but nerves appear to only enter the inter-radicular PDL near the root apex.
2. Longitudinal grooves in the alveolar wall are associated with neurovascular bundles.

Technical Session XIII (Friday, October 11, 2019, 2:00 PM)

AN EXCEPTIONALLY PRESERVED SMALL ARBOREAL REPTILE FROM THE UPPER PERMIAN USILI FORMATION OF TANZANIA

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The Permo-Triassic mass extinction is recognized to have massively reorganized terrestrial tetrapod communities from the synapsid-dominated ecosystems of the late Permian to communities with more reptile diversity in the Early and Middle Triassic. Additionally, evidence of body size changes across this boundary indicate that most early reptiles were small until after the extinction, when they were able to expand into the vacated large-bodied niches. The Ruhi Ruhi Basin of Tanzania documents the latter part of this transition well, with early members of several archosaurian clades present in the Middle Triassic Manda Beds. However, only large pareiasaur parareptiles and a single specimen of the possible early archosauromorph Aenigmastrepsus partitondo are known from the upper Permain Usili Formation, despite decades of collecting that have yielded 24 species of synapsids ranging from tiny Kawingsaurus to hippo-sized Rauhocochphas. Here we report a recently discovered, unique reptile from the Usili Formation that possibly represents the oldest diapsid from Tanzania. CT data reveal densely packed and well-osified, though apparently unduplicated, bony elements, indicating that the specimen represents the remains of a single individual. The taphonomic history of the specimen suggests preservation within a coprolite. This small specimen (estimated humeral length = 21 mm) includes articulated forelimbs and hindlimbs with a humerus with both ent- and ectepicondylar foramina and a distinct capitellum, elongated metapodials and phalanges, and curved and tapered unguals, suggesting an arboreal lifestyle. The combination of elongated caudal vertebrae and morphology of the pelvis and the manus suggest that this amniote is likely a diapsid reptile; however, most character states that this amniote may lack a diapsid reptile. In contrast, most character states that diagnosis this clade lie in the skull, which was not found in this specimen. Additionally, the articulated caudal vertebrae have elongated centra distinct from those of anomodont synapsids, such as the possible arboreal Suminia from the late Permain of Tanzania, further corroborating our identification and indicating an arboreal ecology for at least some small reptiles in the late Permian.

Grant Information:
Funding: NSF EAR1337291, EAR-1337569

Education and Outreach Poster Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)

UNIVERSITY OUTREACH SERVING RURAL COMMUNITIES: WEST VIRGINIA SCIENCE ADVENTURES K-12 STEM SUMMER CAMPS

STRAIT, Suzanne G., Marshall University, Huntington, WV, United States of America; LESTER, Liz, Marshall University, Huntington, WV, United States of America; CANTRELL, Jessica, Marshall University, Huntington, WV, United States of America

Recent studies have shown that as little as 5% of an individual’s lifetime science education comes from a formal classroom setting. Outside of school, science is learned from a variety of informal education venues including museums, science centers, and zoos. Informal education has been shown to promote STEM learning, inform career choice, and encourage diversity. However, in rural areas access to informal education is limited. In such cases it is possible for universities to develop programming, such as science festivals and summer camps, to fill this void matching opportunities typically only found in urban areas.

For the last 7 years West Virginia Science Adventures at Marshall University has offered 9 weeks of STEM summer camps serving approximately 400 K-12 students annually. These week-long camps span many fields including paleontology, geology, astronomy, biology, coding, chemistry, physics, engineering, and math and focus on hands-on, making, and activity-based learning. The goals of these camps are both science enrichment and working towards science inclusion and diversity. It is especially important to make these camps accessible to all members of the community regardless of socioeconomic status. This programming has moved beyond financial self-sustaining, so we are able to provide approximately 35% of our campers with full scholarships based on demonstrated financial need. Earlier camp years
were biased toward boys (typically in the 65% range), with grades 6-8 being the most challenging ages to recruit girls. However, targeted marketing and diversifying camp themes have now succeeded in establishing an even distribution of boys and girls across our age groups.

Our camps are mostly designed and staffed by MS graduate students, giving them a chance for both summer support and outreach experience. Providing university-sponsored camps on campus has two further goals. First, children are exposed to exciting hands-on science with actual scientists, while at the same time de-mystifying college and STEM by exposing children at an early age to campuses and research labs. This place-bound adventure is especially valuable for potential first-generation college students.

Regular Poster Session III (Friday, October 11, 2019, 4:15 - 6:15 PM)

THE SKULL OF A YOUNG JUVENILE ELASMOSAUR FROM THE CAMPAIGN BEARPAW FORMATION OF SASKATCHEWAN, CANADA

STREET, Hallie P., Royal Saskatchewan Museum, Eastend, SK, Canada; MUKARSKI, Michelle C., University of Ottawa, Ottawa, ON, Canada; BAMFORTH, Emily L., Royal Saskatchewan Museum, Eastend, SK, Canada; SMITH, Anthony, McGill Univ, Montreal, QC, Canada; TAHIRA, Rui, McGill Univ, Montreal, QC, Canada; LARSSON, Hans C., McGill Univ, Montreal, QC, Canada

ACROSS CENTRAL NORTH AMERICA DURING THE LATE CRETACEOUS. This inland seaway in Montana represents one of the final transgressions of the Western Interior Sea during the Late Cretaceous. Some of the vertebrate specimens from the Bearpaw Formation in western Canada are preserved in soft tissue, and the presence of such material demonstrates that this inland seaway was inhabited by various marine reptiles including sea turtles, mosasaurs, and both polycotylid and elasmosaurid plesiosaurs. A new Bearpaw site in southwestern Saskatchewan differs from other outcroppings in that fossils including mollusks, arthropods, echinoderms, and vertebrates are preserved in phosphatic concretions. A very small (~13 cm long) elasmosaur skull was discovered inside one such concretion. In addition to the small size, the extremely poorly ossified cranial bones support the interpretation of the specimen as a young juvenile. The preservation of some of the vertebrate material recovered from various concretions at this site, including some regions of the juvenile elasmosaur skull, is atypically glassy and brittle. Therefore, the concretion containing the skull was scanned using micro-computed tomography. These scans reveal that the nearly complete cranium is preserved in three dimensions with little deformation. Preservation of skull elements differs based on developmental origin, with endochondral bones being better ossified and the dermal bones exhibiting the glassy appearance. This difference is particularly apparent in the micro-CT scans, where the dermal elements are difficult to resolve from the matrix of the nodule. Little is known about the timing of ossification in developing plesiosaur skulls, but it is possible that the difference in levels of ossification between the endochondral and dermal bones may indicate that this individual died shortly before or shortly after parturition. If so, this specimen provides a unique opportunity to explore the developmental relationships between the chondrocranium and dermatocranium in plesiosaurs.

Technical Session XII (Friday, October 11, 2019, 10:15 AM)

WHY DID SOME QUADRUPEDAL DINOSAURS HAVE SMALL FRONT FEET?

STRICKSON, Eleanor C., Liverpool John Moores University, Liverpool, United Kingdom; WILKINSON, David M., University of Lincoln, Lincoln, England; HUTCHINSON, John R., Royal Veterinary College, Hatfield, United Kingdom; FALKINGHAM, Peter L., Liverpool John Moores University, Liverpool, United Kingdom

Some quadrupedal dinosaurs have a manus and pes of notably different size, i.e., they exhibit strong heteropody. This is particularly common within the dinosaur fossil record in both skeletons and trackways. Previous hypotheses as to why this might arise have focused on equalization of underfoot pressures relating to centre of mass (CM) position, but this reasoning remains untested. We used 3D models of extant taxa to explore the relationship between manus and pes size, and centre of mass position. Similar approaches have been limited to skeletons, we first set out to understand the relationship between foot surface area of soft and skeletal tissue. 2D alpha shapes of feet derived from CT scans of 29 extant species (mammals, reptiles, birds and amphibians) were used to examine the relationship between skeletal and skin foot surface area and whether it is possible to predict in vivo foot contact area from fossil foot remains. Underfoot soft tissue area was found to be ~1.67 times that of skeletal surface area. When manus and pes were analysed separately, this number was ~2 times for manus and ~1.6 times for pes, with a high degree of predictability. 3D models of complete skeletons from 57 extant, quadrupedal animals (mammals, crocodiles, and lepidosaurs), were collated. CM positions for each specimen as a young juvenile. The preservation of some of the vertebrate specimens from the DCB includes many elements that are common in the pre-Bearpaw Dinosaur Park Formation (DFP) of southern Alberta, such as chasmosaurs, trionychid turtles, and baenid turtles including Plesiobaena antiqua. However, the DCB assemblage differs from that of the DPF in that acipenserid fish, chelidrid turtle and theseselosauri ornithischian elements are relatively abundant, while crocodilians are known from only one tooth. A caenagnathid mandible from the DCF resembles Chirostenotes from the DPF, but it was very small. This bone may be juvenile, but the DCB chasmosaurs are also small, and large turtles such as Adocus are absent. A juvenile lambeosaurine found near the DCF is comparable to Corythosaurus, but may be a new taxon given its tridem-like nasal. Similarly, the KH fauna resembles that of the DFP, but shows a few novelties, notably the presence of abundant troodontid teeth and the unique lizard Kleksaurus. The Unit 3 fauna differs in detail but not in general composition from slightly older, more southerly Campanian ones, given the few known distinctive species and high abundances of some groups. However, the fact that Unit 3 coincides with a gap in the southern Alberta terrestrial record implies that some oddities of the Unit 3 fauna may result from sampling of an otherwise poorly represented time. The near-absence of crocodilians and the small size of the turtles and chasmosaurs are perhaps most likely to reflect a true latitudinal signal, given latitudinal constraints on the size and distribution of ectotherms today.

Grant Information:
This study was undertaken as part of the Philip J. Currie Professorship at the University of Alberta, supported by the River of Death and Discovery Dinosaur Museum Society.
A new basal pelycosaur-grade synapsid, family Caseidae, is described on the basis of four partial to nearly complete articulated skeletons from the Bromacker locality, in the Lower Permian Tambach Formation, lowermost fossiliferous unit of the Upper Rotliegend Group or Series, near the village of Tambach-Dietharz in the mid-region of the Thuringian Forest, central Germany. Based on its highly diverse vertebrate assemblage the age of the Bromacker locality is judged middle Early Permian Artinskian. The specimens comprising the new caseid present nearly complete knowledge of its skeletal morphology. It is the first caseid to be reported from Germany and can be distinguished readily from all other caseids based on a substantial list of autapomorphic and plesiomorphic characters. Of the four new caseid specimens, the smallest, a juvenile, and the largest, an adult, are nearly complete, articulated, and possess cranial material: in the juvenile a small partially articulated portion of the skull, and in the adult an essentially complete but crushed skull. The two specimens can be distinguished from one another by features attributed to different ontogenetic stages of development, including degree of ossification, differences in the proportions of the pre- and post-zygomatic portions, and marginal denticles. Notably, the lattest difference is interpreted as evidence of a deciduous dentition. Extremely small tubular teeth in the juvenile suggest an insectivorous diet are replaced in the adult by much larger, narrowly triangular, slightly recurved, and distally pointed teeth suggestive of an omnivorous diet. Although the presumably insectivorous teeth of the juvenile lack the crowns, they are otherwise very similar to those reported in the oldest known caseid, the Late Pennsylvanian holotypic juvenile specimen Eocasea martini, which were argued as evidence of a non-herbivorous diet. The dentition in E. martini has been argued as further evidence that herbivory evolved within caseidae. Cladistic analysis suggests E. martini as the most basal member of the monophyletic Caseidae and the later occurring middle Early Permian and the new German caseid as the sister taxon of the remaining late Early and Middle Permian members of the clade. Series of relationships, as well as the ontogenetic trajectory shown in the new German caseid’s dentition, both parallel a proposed chronology of evolutionary changes in the dentition and associated diets of caseids.

Grant Information: National Geographic Society; Edward O’Neil Endowment Fund, M. Graham Netting Research Fund, Carnegie Museum of Natural History; Deutsche Forschungsgemeinschaft.

Education and Outreach Poster Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)

THE PATTERNS PROJECT - PHYLOGENY-DRIVEN, ANATOMICAL TAXON TRANSFORMATION AS EDUCATION RESOURCE FOR NATURAL SCIENCES: USING DIGITAL MORPHING ANIMATION TO INTERPOLATE STRUCTURES AND ENHANCE EDUCATION AND OUTREACH IN VERTEBRATE PALEONTOLOGY

SUMIDA, Stuart S., California State University San Bernardino, San Bernardino, CA, United States of America; WALKER, Sian, University of Bournemouth, Poole, United Kingdom

The PATTERNS Project was initially envisioned as a means to bring virtual reality projects to children by appealing to them with a medium similar to video games and hand-held device apps. When phylogenetic hypotheses are incorporated into the outreach resources, they provide a natural way to bring evolutionary theory, earth history, and deep time into educational tools. Successful integration into such materials demands increasingly visual interactive components. This facilitates their incorporation into stationary presentations such as museum displays, but also mobile devices. A visually enhanced phylogeny becomes: (1) a tool with which students, scientists, and artists can observe the morphological transformations necessary between known, described taxa; and (2) a hypothesis generator for possible, plausible intermediate taxa within a phylogeny. This is achieved by utilizing the ability of computer modeling and animation software to morph from one predefined shape to another. To this end, a demonstration of the strategy was undertaken using a basal diadectomorph tetrapod, Limnoscelis, and two well-known pelycosaurs-grade sphenacodontid synapsids: the “sail-less” Sphenacodon, and the iconic sail-backed Dimetrodon. Using software packages generally employed in the visual effects and computer animation industries, digital sculptures of each were generated based on accepted body proportions of complete skeletons, and conservative estimates of surface shapes of their bones. This example allows users to track the relatively subtle differences in head shape and dentition between the basal diadectomorph and synapsid. It also allows users to monitor the much more dramatic change accompanying the development of a sail within sphenacodonts. This system is being developed primarily to demonstrate relationships between known forms, but may serve to generate hypotheses of intermediates between known forms. Focusing on a gap between modeled taxa, interpolation techniques demonstrate the range of morphological possibilities between taxa and can be predict them in a visually direct way. The patterns project is being incorporated into the outreach resources, they provide a natural way to bring evolutionary theory, earth history, and deep time into educational tools. Inverting this relationship, we see in the PATTERNS project an education and outreach tool that becomes a hypothesis generator for paleontological research.

Grant Information:
1) Georg Forster Research Fellowship—Alexander von Humboldt Foundation
2) Grants for Development of New Faculty Staff (Chulalongkorn University)
A THEROPOD REMAIN FROM THE UPPER CRETACEOUS YEZU GROUP, HABOROGAWA FORMATION IN ASHIBETSU CITY, HOKKAIDO PREFECTURE, JAPAN

SUZUKI, Hana, Hokkaido University, Hokkaido, Japan; KOBIYASHI, Yoshitsugu, Hokkaido Univ, Hokkaido, Japan; KANO, Manabu, Mikasa City Museum, Hokkaido, Japan; KARASAWA, Tomoki, Mikasa City Museum, Hokkaido, Japan; HAYASHI, Shoji, Okayama, Japan; OTA, Akira, Mukawa Town Hall, Hokkaido, Japan; MIYAJI, Tuzumi, Preparatory Office for National Aimb Museum, Hokkaido, Japan

Dinosaur records from Japan have been increased in last three decades, but many of these fossils have been recovered from the Lower Cretaceous deposits. Recently, dinosaur remains from the Late Cretaceous have been discovered from the northernmost (Hokkaido) and southernmost (Kyushu) main islands of the country. Hokkaido exposes the Upper Cretaceous Yezu Group, which consists mainly of marine sediments and occasionally yields vertebrate fossils such as plesiosaurs, mosasaurs, marine turtles, and dinosaurs. Dinosaur remains from the group include a nodosaurid from the Hikagensawa Formation (Cenomanian), a maniraptoran from the Osoushina Formation (early Campanian), and two hadrosaurids from the Hakobuchi Formation (Maastrichtian) and from an unidentified locality of the Yezu Group.

In 2016, an isolated centrum, 89 mm long, was newly discovered from a sandstone layer of the Haborogawa Formation (Coniacian to early Campanian), which underlies the Hakobuchi Formation. The stratigraphic position of the dinosaur-bearing horizon suggests that it is dated as the late Coniacian in age. The spool-shaped centrum has paired triangular chevron facets and a dense cancellous bone and thin cortical bone with a large internal cavity at the convexity of the centrum based on transverse CT images, indicating that it is a caudal vertebra of a theropod dinosaur. It preserves the base of a transverse process and has a low height-length ratio (0.63), suggesting that it is a mid-caudal centrum near the antero-posterior caudal transition point. This centrum also shows similarities with tyrannosaurids in a height-length ratio less than 1, round edges of intervertebral articular surfaces, and amphicoelous centrum with deeper concavity of anterior surface than posterior one. The size of the centrum is comparable to “medium-sized” tyrannosaurids such as Timurlengia from Turonian of Uzbekistan.

This centrum is the first dinosaur remain from the Coniacian Haborogawa Formation and the fifth from Hokkaido, filling the temporal gap of dinosaur records in this region and suggesting continuous existence of dinosaurs along the coast of the northern Far East during the Late Cretaceous. It also supports the previous hypothesis that the early Late Cretaceous may have been an important time for a body size transition from small (Late Jurassic to Early Cretaceous) to large (late Late Cretaceous) sized tyrannosaurids.

THE FIRST COMPREHENSIVE RECORD OF ELASMOMBRANCHS FROM THE MID-PALAEOCENE BONGEROODA GREENSAND MEMBER OF WESTERN AUSTRALIA

SYME, Caitlin E., Office of the Queensland Chief Scientist, Brisbane, Australia

The first comprehensive record of elasmobranchs from the mid-Paleocene (upper Selandian–Thanetian) Boongerooda Greensand Member of Western Australia was compiled through bulk sampling and identification of isolated elasmobranch teeth. Four teeth potentially belonging to two new genera (Hexanchidae gen. indet.) and two new species (Galeorhinus n. sp., and one Scyliorhinus n. sp) were identified, all left in open nomenclature. A large number of isolated teeth from Weltonia sp, Sirodamia sp., Isorolamna inflata, Fournitiza sp., F. abdonii, Galeorhinus mesestus, Paleogaleus larachei, Triakis antarcti and Turpeo domalaeolensis were also identified. These taxa have been described from Paleocene (Thanetian) deposits in Europe, North America and North Africa, indicating that they were cosmopolitan. The presence of one tooth with affinities to Turpeo domalaeolensis is the second pre-Messinian report of this species worldwide. The majority of teeth found in the Boongerooda Greensand Member are poorly preserved (rounded or splintered) with less than 3% of the elasmobranch teeth found completely intact. The presence of poorly preserved elasmobranch teeth throughout the Boongerooda Greensand Member suggest the depositional environment was in shallow water or an open marine environment above storm wave base. Analysis of planktic foraminiferal species from the Boongerooda Greensand Member indicates a tropical warm temperate depositional setting with a depth of 50–100 m. While the presence of Hexanchidae is normally an indicator of a deep-water (200 m) environment, their presence in the shallow (50–100 m) Boongerooda Greensand Member suggests that they are not an explicit indicator of deeper water environments.

The presence of deeper water hexanchids into shallow water environments was not restricted to Australia, having also been recorded in Paleocene deposits in Europe and New Zealand. The movement of taxa from areas such as Northern Africa into Europe and Australia may also be the result of an ecological change brought about by the K-T boundary extinction event, such as an increase of vacant ecological niches.

Grant Information: This research was supported by the National Science Centre, Poland grant 2016/23/N/NZ8/01823.

AN EARLY LATE TRIASSIC RHYNCHOCEPHALIAN FROM NORTHERN PANGAEA SUGGESTS RELIC NATURE OF SOME BRITISH RHAETIAN VERTEBRATE ASSEMBLAGES

TALANDA, Mateusz, University of Warsaw, Faculty of Biology, Warsaw, Poland; SULEJ, Tomasz, Institute of Paleobiology, Polish Academy of Sciences, Warsaw, Poland

This paper describes a new rhynchocephalian, Proganochelys (PROTEROCHERSIDAE)

This research was supported by the National Science Centre, Poland grant 2016/23/N/NZ8/01823.

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LOOSENING THE MACROEVOLUTIONARY Ratchet: Does Dietary Plasticity Alter Morphological Insights into Canid Evolution?

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The macroevolutionary ratchet, exemplified by the canid family (Mammalia: Carnivora), is a pervasive pattern of iterative clad replacement whereby increasingly specialized species are eventually driven to extinction and replaced by younger, more generalized species. However, specialization and its link to extinction has traditionally been inferred from morphological traits alone (e.g., body mass, molar surface area) rather than from direct dietary reconstructions. While a species’ morphology reflects its overall dietary capability, individuals frequently forage in ways that morphology cannot predict. Thus it is the dietary plasticity of populations, which isn’t captured by morphology, that truly defines a species’ dietary specialization. I tested the association between dietary specialization and lineage extinction by quantifying the dietary niche of 9 extinct species (representing the Hesperocyninae, Borophaginae, and Caninae subfamilies) over the past 33.3 million years of Canidae evolution using Dental Microwear Texture Analysis (DMTA). DMTA quantifies microscopic wear patterns on tooth enamel that specialization was calculated using multi-dimensional Bayesian ellipsoid reconstruction. While a species’ morphology reflects its overall dietary specialization, individuals frequently forage in ways that morphology cannot predict. Thus it is the dietary plasticity of populations, which isn’t captured by morphology, that truly defines a species’ dietary specialization. I tested the association between dietary specialization and lineage extinction by quantifying the dietary niche of 9 extinct species (representing the Hesperocyninae, Borophaginae, and Caninae subfamilies) over the past 33.3 million years of Canidae evolution using Dental Microwear Texture Analysis (DMTA). DMTA quantifies microscopic wear patterns on tooth enamel that capture a comprehensive picture of dietary resource use. Species’ dietary specialization was calculated using multi-dimensional Bayesian ellipsoid volumes of DMTA parameter space and correlated with their duration as estimated using DMTA. I found dietary specialization to be a better predictor of species duration than all considered measures of morphology, including the commonly used metric of body mass (MAIC > 2). DMTA data also suggested hypercarnivory is positively linked to body mass, consistent with metabolic scaling theory. Counter to expectations, I observed a positive correlation between specialization and lineage duration (p < 0.05; \( R^2 = 0.38 \)), that specialization was lowest for canids of intermediate body mass, and that specialization was not correlated with traditionally-used dietary categories (i.e., hypo-, meso-, or hypercarnivory). My results therefore run counter to the macroevolutionary ratchet hypothesis, suggesting that overspecialization in diet alone was not enough to drive iterative extinctions in canids. Instead, I suggest that dietary specialization offers selective advantages during times of fluctuating prey abundance that facilitated the coexistence of a diverse canid assemblage in the Tertiary.

Grant Information:
SVP Albert E. Wood Award 2018
OSU Paul & Mary Roberts Evolutionary Biology Fellowship 2017
ASM Grant In Aid of Research 2015

Fossil Bird Bones from the Subantarctic Auckland Islands

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Thousands of Holocene fossil bones were collected between 1963 and 2018 from dune deposits on the uninhabited subantarctic Auckland Islands, south of New Zealand. The island group has a rich seabird fauna and a distinctive land bird fauna with many endemic taxa. However, between 1840 and 2000 at least four extinctions occurred due to predation by introduced mammals and human hunting (a duck Mergus australis; two petrels Pelagodroma marina and Pelecanoides georgica; and a plover Thinornis novaseelandiae). The fossil fauna is dominated by small seabirds still found at the island group (diving petrels Pelecanoides spp. and prions Pachyptila spp.) but a wide range of other taxa have also been found, including nearly all species that breed at the island group today. Several vagrant seabird taxa were found, including king penguin Aptenodytes patagonicus and Kerguelen petrel Lemprea brevirostris. Additionally, fossils have revealed one previously unknown extinct species (a raven Corvus sp.) and that some taxa used to be more widespread, e.g., the Auckland Island rail Lewinia muelleri formerly lived on Enderby Island. This information on prehistoric distributions will assist the management of the avifauna of the Auckland Islands which is currently the subject of a major ecological restoration programme.

Grant Information:
Dinosaur Research Institute Grant

Mysteries of Metoposaurus – Paleoichthyology Helps to Understand Interspecific Variety among Late Triassic Amphibians

TESCHNER, Elbieta M., Opole University, Opole, Poland; KONIETZKO-MEIER, Dorota, Steinmann Institute, Bonn, Germany

Temnospondyls is a large clade of extinct amphibians, with cosmopolitan distribution and widespread occurrence across different geologic periods. These animals have been present in rocks from the Late Triassic to the Early Cretaceous. Metoposaurus is a group reported only to the Late Triassic in the New Zealand known worldwide (Poland, Germany, Portugal, Morocco, and India). It makes metoposaurus the excellent case to find out histologically how the growth pattern varies in one taxon but from different geographical localities and finally to check if and how the local conditions did influence the growth. The analyzed material includes Metoposaurus krasiejowensis from polish locality Kraisiejow, Dutitosaurus ouazzoui from Morocco and Panthasaurus maleriensis from India. The paleoichthyological analysis was conducted on long bones (21 humeri and 24 femora) from different localities. On the histological level, all taxa represent common pattern independent of the locality with the dominance of parallel-fibred bone mixed with lamellar bone and similar organization of the vascular canals. The most important differences between localities are observable in the origination of the growth marks (thickness of the zones and annuli and presence of the Line of Arrested Growth). In Metoposaurus krasiejowensis two growth systems has been observed (H1 represents an alternating growth; H2 represents a rapid growth) which are not connected to the size and individual age of the bone. The typical LAGs are not observed here. Dutitosaurus shows both histological patterns first with thick zones, thin annuli, and annual LAGs and the second with rapidly growing zones. Panthasaurus maleriensis represents both histotypes of M. krasiejowensis but as an age-dependent system (small bones - rapid growth, larger bones - alternating growth). For Metoposaurus and Dutitosaurus the expressed pattern is strictly related to the local climate. The lack of typical, annual LAGs in both histotypes of
Metoposaurus inform that the local conditions were milder in Krasiejów, and even during a dry season, slow growth was possible. Very dry conditions and was forced to annual aestivations, expressed as regular LAGs. Panthasaurus after the juvenile phase of the fast growth shows the alternation, which could mirror the change of the ecological niche by an age. However, currently the explanation of this phenomenon is not possible and other methods, e.g., geochemistry, need to be applied.

This research has been funded by the Polish Centre of Sciences (NCN) Preludium, grant number UMO-2016/23/N/ST10/02179.

Grant Information:
This research has been funded by the Polish Centre of Sciences (NCN) Preludium, grant number UMO-2016/23/N/ST10/02179.

TECHNICAL SESSION XIV (Friday, October 11, 2019, 4:00 PM)
RECRUITMENT OF CROWN-CLADE PENGUINS INTO NEW ZEALAND

THOMAS, Daniel B., Massey University, Auckland, New Zealand; KSEPKA, Daniel T., Bruce Museum, Greenwich, CT, United States of America; SCOFIELD, Paul, Canterbury Museum, Christchurch, New Zealand; HEATH, Tracy A., Iowa State University, Ames, IA, United States of America; PETT, Walker, Iowa State University, Ames, IA, United States of America; HOLVAST, Emma, Massey University, Auckland, New Zealand; TENNYSON, Alan J., Museum of New Zealand Te Papa Tongarewa, Wellington, New Zealand

Around one quarter of the world's approximately 360 extant seabird species breed in New Zealand today. Resolving the factors that led to the alternation, which could mirror the change of the ecological niche by an age. However, currently the explanation of this phenomenon is not possible and other methods, e.g., geochemistry, need to be applied.

Grant Information:
Supported by an Australian Government Research Training Program Scholarship

Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)
SAUROPOD DINOSAUR TRACKS AND ASSOCIATED SEDIMENTARY STRUCTURES IN THE BROOME SANDSTONE (CRETACEOUS) OF WESTERN AUSTRALIA.

THULBORN, Tony, Brisbane, Australia

Since the early 1990s ongoing research has revealed the existence of many and varied sauropod tracks in coastal exposures of the Broome Sandstone (Lower Cretaceous, Valanginian?) of the Dampier Peninsula, in the Kimberley region of Western Australia. This ichnofauna constitutes practically the entire record of dinosaurs in the western half of the Australian continent and is distinctly more ancient than the better-known Cretaceous dinosaur faunas of eastern Australia (Queensland, Victoria). The dinosaurian ichnofauna includes evidence of ichnocoenosis and geographic origins of the New Zealand seabird fauna has been hindered by a generally sparse fossil record for most seabird lineages. Penguins (Aves: Sphenisciformes) are the exception, and a well-preserved group of Ploceine penguin fossils from New Zealand provide some of the first insights into long history for crown seabird genera in the region. We have discovered an extinct species within the crested penguin genus Eudyptes from Late Pleistocene sediments (ca. 3 Ma) in the North Island of New Zealand. Several endemic species within Eudyptes live in the region today that raises the possibility that New Zealand has been continually inhabited by this genus for at least the last several million years. The Ploceine Eudyptes is represented by bones from several individuals and is principally distinguishable from extant congeners by cranial morphology. The Ploceine species has a more-slender bill compared with extant crested penguins. Using phylogenetic analysis of variance we find that krill are an important source of food for living penguins that have relatively deep bellies, which includes most extant Eudyptes. Ancestral state reconstruction methods suggest that that the mandible deepened during the crown radiation of Eudyptes which may reflect a change in diet over time for this group. The discovery of the Ploceine Eudyptes species sheds new light on similarly-aged penguin material from New Zealand. Ancestral area estimates across a phylogeny inferred with Bayesian methods indicate that Eudyptes and the closely related yellow-eyed penguins (Megadyptes) have lived in the New Zealand region since at least the Early Pliocene.

Grant Information:
Massey University Innovation and Excellence Grant

Romer Prize Session (Thursday, October 10, 2019, 10:30 AM)
ONE SKIN, TWO SKINK, BIG SKINK, BLUE SKINK: MIocene ORIGINS AND PlIO-PLEISTOCENE GIGANTISM IN THE AUSTRALASIAN GENUS Tiliqua (SQUAMATA: SCINCIDAE)

THORN, Kailah M., Flinders University, Aberfoyle Park, Australia

The social lizards of the Egerniinae repeatedly evolved large body sizes; one species now the world's largest living skink. Nowhere is this trend towards gigantism more apparent than within the charismatic blue-tongue lizards of the genus Tiliqua. I examine how and when this group managed to grow so large, how their body shapes became so diverse and I explore how a pygmy species appeared amongst giants. Discrete and continuous morphological characters, combined with molecular data, were analysed with both parsimony and tip-dated Bayesian methods. Three fossil Tiliqua species were added to these analyses, Tiliqua puvilla, a tiny middle-Miocene taxon; Tiliqua wilkissonorum, a large Pliocene taxon; and Tiliqua frangens, an extinct Pleistocene 'megafuchsia' shingleback. The resulting tip-dated total-evidence phylogeny suggests that the most rapid morphological evolution in the Egerniinae, in the Oligo-Miocene, produced the highly distinctive body forms typical of Tiliqua, and the clade Cyclodomorphus. Within Tiliqua, phyletic gigantism began after the middle Miocene, and peaked in the Plio-Pleistocene with two giant taxa. There are also examples of: autapomorphic nanism, which produced the endangered pygmy Tiliqua adelaidensis, sister taxon to one of the largest extinct eugermes, T. rugosa; and phyletic nanism, a trend in decreasing body size which produced the clade inclusive of the small Cyclodomorphus, slow growth was possible. Knowledge of how and when these body size changes occurred would not have been possible without a total-evidence phylogeny of this group. This investigation has uncovered another exception to Cope's rule that body sizes grow larger through evolutionary time, and highlighted the morphological diversity of Australia's previously underrepresented fossil herpetofauna.

Grant Information:
Supported by an Australian Government Research Training Program Scholarship

Regular Poster Session I (Wednesday, October 9, 2019, 4:15 - 6:15 PM)
CRANIAL MORPHOLOGY OF HISangolestes (Mammalia; Insectivorida) and Naranius (Mammalia; Cimolesta) and Phylogeny of Basal Insectivores

TING, Su lin, Louisiana State Univ, Baton Rouge, LA, United States of America; WANG, Xiong, Natural History Museum of Los Angeles County, Los Angeles, CA, United States of America; MENg, Jin, American Museum of Natural History, New York, NY; United States of America

Recent studies of Hisangolestes youngi and a new species of Naranius, based on complete and partial skulls and mandibles, provide detailed information on their cranial morphology and shed new light on their phylogenetic position and the relationships of early insectivores. New materials of these taxa were discovered from the Early Eocene Lingua Formation, Hengyang Basin, China, where the negative excursion in 13C values marking the Paleocene-Eocene boundary was recognized. Specimens were collected from the sediments about 15m above the Paleocene-Eocene boundary. These fossils were involved in the faunal transition and exchange in response to the global climate warming.

We coded 290 dental and cranial characters and selected 36 species for the phylogenetic analysis. Hisangolestes youngi is a taxon endemic to Asia. It is a genus initially placed in the family Didymocnoidei, order Insectivora, later grouped under order Cimolesta, and then referred to family Microteromomontidae, order Lipotyphla. Our study shows that Hisangolestes youngi is closely related to Sinosinopina sinensis, Sarcodon pygmaeus, and Proscuscerdon lomanensis, for which we suggest creation of family Naranius...
Sarcodontidae, Insectivora incertae sedis. Given the only known cranial character, lacking a large contribution to the orbital wall of the maxilla, of *Hsiangolestes youngi*, we suggest excluding Sarcodontidae from Lipotyphla.

The taxa in Sarcodontidae previously assigned to Micropternodontidae are mainly based on large hypcone and expanded hypcone-shelf of upper molars; however, these characters in sarcodontids differ from those of the latter. Family Micropternodontidae may better be restricted to Micropternodus borealis and its North American allies.

The type species of *Narutius, N. infrequens*, is from Early Eocene Bumble Member of Narutis, Bulak Formation, Tuvhorsk, Mongolia, and was a genus in the family Paleoryctidae, order Proteutheria, of Mongolia, and was a genus in the family Paleoryctidae, order Proteutheria, of the latter. The new species differs slightly from the type species in the cranial morphology. Our study indicates that *Narutius* is well clustered with *Cimolestes*. The early known species of *Narutius* outside of Asia, *N. americanus* from Tuscahoma Formation, Lauderdale County, Mississippi, United States, is represented by two isolated molars. Its dental similarities to the molars of *Narutius* are mainly primitive characters, and the classification is uncertain.

Regular Poster Session III (Friday, October 11, 2019, 4:15 - 6:15 PM)

**AN EARLY-DIVERGING CROCODYLOMORPH FROM THE EARLY NORIAN (LATE TRIASSIC) OF DOCKUM GROUP, TEXAS**

TO, Khanh H., Virginia Tech, Blacksburg, OK, United States of America; NESBITT, Sterling J., Virginia Tech, Seattle, WA, United States of America; STOCKER, Michelle R., Virginia Polytechnic Institute and State University, Blacksburg, VA, United States of America

Archosaurs, after first diversifying by the Early Triassic, continued their diversification into the Late Triassic, specifically the late Carnian to early Norian. Within this radiation, the coeval diversification of dinosaurs and crocodylomorphs (pseudosuchian clade more closely related to crown Crocodylia than to aetosaurs, rauisuchids, poposauroids, phytosaurs, and ornithischials) appeared in the fossil record. However, the precise timing of the diversification, order of anatomical transformations, and biogeographic patterns of early crocodylomorphs are poorly understood. The oldest forms (231-227 Ma) are from higher latitudes (e.g., *Trialestes* from Argentina), whereas the fossil record in low latitudes (e.g., *Dromicosuchus* and CM 73372 from North Carolina and New Mexico, respectively) lies in younger strata (early and late Norian, respectively). Thus, the Carnian and earliest Norian record remains unclear. However, the Otis Chalk localities in the Dockum Group of Texas host one of best known early Norian terrestrial faunal assemblages, including early diverging forms of temnospondyls, dinosauromorphs, and crocodylomorphs. Here we describe the first early-diverging crocodylomorph from the Otis Chalk localities, represented by TMM 31100-1494, a nearly complete right ilium. This ilium has a concave ventral acetabulum edge, a supra-acetabulum buttress, and a hypothesized long anterior process, bracketing the specimen as an early-diverging crocodylomorph similar to CM 73372. The presence of this taxon in the Otis Chalk localities fills in both a chronologic and geographical gap for early-diverging Crocodylomorpha. The Otis Chalk localities were biochronologically constrained to be 8-11 million years older than those of *Dromicosuchus* and *Hesperosuchus* but still younger than the *Trialestes* localities. Geographically, this specimen connects the known range of the clade from southern high latitudes (*Trialestes*) to the low latitudes that suggests that crocodylomorphs were widespread across what is now North America early in their history. The Otis Chalk crocodylomorph adds to the wide array of early-diverging crocodylomorphs present in the Late Triassic and shows that early members of this clade diversified across a wide range of paleolatitudes.

Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM)

**REFINED AGE AND GEOLOGICAL CONTEXT OF TWO OF AUSTRALIA’S MOST IMPORTANT JURASSIC VERTEBRATE TAXA (RHETOZOAURUS BROWNEI AND SIDEROPS KEHLI), SURAT BASIN, QUEENSLAND**

TODD, Christopher N., James Cook University, Townsville, Australia; ROBERTS, Eric M., James Cook University, Townsville, Australia; KNUTSEN, Espen, Queensland Museum, Townsville, Australia; ROZEFELDS, Andrew, Queensland Museum, Brisbane, Australia; HUANG, Hui-Qing, James Cook University, Townsville, Australia; SPANDLER, Carl, James Cook University, Townsville, Australia

The current Jurassic vertebrate fossil record in Australia is extremely sparse, with only two temnospondyl amphibians and two dinosaur taxa identified to date. Remains of several freshwater pleiosaurs have also been uncovered; however, these are still unnamed. Of the identified taxa, the spectacular and extremely well-preserved giant amphibian, *Siderops kehli*, and the only known pre-Cretaceous sauropod in Australia, *Rhoetosaurus brownei*, are perhaps the most important. The age of both specimens, and the stratigraphic context of *Rhoetosaurus brownei*, are widely constrained and impressively defined, which limits our understanding of their evolutionary relationships within a broader Gondwanan context. To clarify and contextualise the evolutionary relationships and ages of these two iconic Jurassic taxa, we used U-Pb detrital zircon geochronology to date the sandstone matrix from around the bones of these historic Queensland Museum specimens. A robust maximum depositional age for *Siderops kehli* was calculated at 176.6 Ma ± 2.0 Ma, indicating that it is no older than late Toarcian, which refines existing biostratigraphic estimates. The depositional age for *Rhoetosaurus brownei* was determined at 162.6 ± 1.1 Ma, no older than early Oxfordian, demonstrating that the fossils are much younger than expected, and confirms a Walloon Coal Measures stratigraphic origin.

Grant Information:
Supported by the Australian Research Council Discovery Projects scheme (Jurassic Arc: Reconstructing the Lost World of Eastern Australia Project [DP180102851]).
2000 students worked in this summer course that allowed them experience paleontological outreach work for the first time in many occasions. The summer course was not opened for three years until 2017 and has gained popularity in this last two years that has been reinstated. The course is opened to undergraduate and graduate students from all disciplines, so it is not limited to geology and biology students. During the course, students learn techniques in restoration and preservation of paleoichnological sites, not only in theory, but applying those techniques directly to the sites under supervision. Also, they have the opportunity to learn the application of new technologies, such as photogrammetry, that are used nowadays in paleoichnological studies and conservation. Students are also, given research projects to develop at the site and are encouraged to present the results at young researchers’ conferences and seminars. They also have the opportunity to attend to an employment workshop so they can learn all the options paleontology has to offer. Paleontological sites are chosen, not only because of their scientific value, but also for the outreach potential they have. The sites are always very near to towns and in touristic routes so we can combine paleontological outreach with fieldwork. In this way we can communicate directly with the visitors and complement the work done at the local paleontological centers to promote the paleontological heritage in the region. Associated to the summer course we organize a series of conferences, open to the public, so we can show new paleontological discoveries and invite national and international researchers to share their work. Therefore, this summer course at University of La Rioja is not only a good opportunity for undergraduate and graduate students to gain experience at fieldwork and research but also an opportunity to promote paleontology as a useful tool for outreach and economic development of the region through tourism.

Symposium: Origin of a Sunburnt Country (Saturday, October 12, 2019, 9:30 AM)

FOSSIL EVIDENCE FOR A MIOCENE TURNOVER IN AUSTRALIAN BANDICOOT DIVERSITY AND A PILOCOE ORIGIN FOR THE MODERN GENERA

TAVOUILLON, Kenny, Western Australian Museum, Welshpool, WA, Australia; MYERS, Troy, University of New South Wales, Bowral, Australia; BLACK, Karen H., University of New South Wales, Sydney, Australia; GUROYICH, Yamila, University of New South Wales, Sydney, Australia; BECK, Robin, University of Salford, Salford, United Kingdom; LOUYS, Julien, Griffith University, West End, Australia; PRICE, Gilbert, The University of Queensland, Redbank Plains, Australia; ARCHER, Michael, University of New South Wales, Maroubra, Australia; HÄND, Suzanne J., University of New South Wales, Sydney, Australia; MURRIHEAD, Jeannette, University of New South Wales, Sydney, Australia

The middle Miocene climate oscillation (MMCO) is a major climatic event that led to the extinction of many vertebrate lineages and diversification of many others. The fossil record of Peramelemorphia, an order of marsupials that includes bandicoots and bilbies, is best represented in Miocene deposits of the Riversleigh World Heritage Area, northwestern Queensland. Prior to the MMCO, peramelemorphians were highly diverse, occupying niches (medium-sized carnivore and small insectivore) that are today occupied by dasyurimorphians. After the MMCO, several peramelemorphian genera disappeared, vacating some of these niches. We present here a new synthesis of the diversity of peramelemorphians before the MMCO, including recognition of a new genus and species that exhibits features (enlarged lower molars) that are unlike those of any previously known peramelemorphian. These unique features may relate to some specific resource or challenge present in Miocene rainforests that did not survive the post-oscillation contraction of these previously widespread closed forests. We compare the diversity of pre-, to post-miocene Miocene and Pleocene of peramelemorphians. We also present a new phylogenetic overview, including the new genus and species that incorporates both molecular and morphological data. Our results suggest that modern peramelemorphians underwent an adaptive radiation triggered by the extinction of medium-sized peramelemorphian carnivores and small peramelemorphian insectivores and speculation of the medium-sized omnivores, caused by long term climate change.

Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)

TAPHONOMIC ANALYSIS OF AUSTRALIAN OWL PELLET ASSEMBLAGES AS ANALOGUES FOR QUATERNARY DEPOSITS AT NARACOORTE CAVES, SOUTH AUSTRALIA

TRELAR, Jessie-Briar, The University of Adelaide, Adelaide, Australia; REED, Elizabeth H., The University of Adelaide, Naracoorte, Australia

Quaternary vertebrate fossil assemblages from caves are a crucial resource of palaeoecological information, particularly for small mammals which often are the most abundant vertebrates represented in these deposits. The World Heritage listed Naracoorte Caves in South Australia have multiple finely resolved deposits that span a near continuous record of the last 500,000 years. Naracoorte assemblages are diverse, although few taxa are contemporaneous in deposits with megafauna, other vertebrates, plants remains and paleoclimate proxies. Small mammal paleoecological data can be used to help answer crucial questions about past environments and provide insights into past vertebrate community responses to change over key periods such as the megafauna extinction window.

The major accumulator of small mammal remains in caves is generally considered to be via regurgitated remains in owl pellets; however, other potential modes of accumulation for small mammals may contribute remains. Taphonomic biases in these cases are not fully understood and lead to misleading paleoecological interpretations. We investigated the modern taphonomic signatures of small mammal bones from the pellets of five Australian owl species and developed a categorical system for the modifications (breakage type, corrosion and size) produced by each owl species. The modern analogue examples were compared with Quaternary fossils from two Naracoorte cave deposits to assess the proportion of small mammal remains that were deposited via owl pellets (and which owl species was responsible), and the proportion that accumulated via other modes such as pitfall entrapment.

As small mammal remains are important paleoecological indicators it is crucial that biases are fully understood and considered when making paleoecological interpretations. Our study provides a taphonomic model to facilitate thorough analysis of small mammal paleoecology at the Naracoorte Caves. These data will allow for a greater understanding of how small mammal remains are deposited in cave systems in Australia and as these systems are similar in other continents this study will have applications to small mammal paleoecology elsewhere.

Symposium: From Molecules to Macroevolution (Wednesday, October 9, 2019, 8:45 AM)

EXCEPTIONAL 3D PRESERVATION OF SOFT TISSUES AND ORGANS IN THE VERTEBRATE FAUNA FROM THE LATE DEVONIAN GOGO FORMATION

TRINAJSTIC, Kate, Curtin University, Perth, Australia; LONG, John A., Flinders Univ, Adelaide, Australia; SANCHEZ, Sophie, Uppsala University, Uppsala, Sweden; BOISVERT, Catherine A., Curtin University, Bentley, Australia; SNITTING, Daniel, Uppsala University, Uppsala, Sweden; TAFFOREAU, Paul, European Synchrotron Radiation Facility, Grenoble, France; DUPRET, Vincent, The Australian National University, Canberra, Australia; CURRIE, Peter, Monash University, Melbourne, Australia; ROELOFS, Brett, Curtin University, Perth, Australia; AHBLEGER, Per E., Uppsala Univ, Uppsala, Sweden

The Gogo Formation has long been recognized for the exceptional 3D preservation of original bone in a diverse vertebrate and invertebrate fauna that once inhabited the Frasian reef environment. Fossils were first collected in the late 1960s; however, it was not until 2000 that the first soft tissues were recognized. The first soft tissues recovered from vertebrae were small patches of muscle in placoderms (basal jawed vertebrates) which had been removed from carbonate nodules by acetic acid. Recent collecting has shown that soft tissue in varying amounts and preservation styles in all taxa from the Gogo Formation. To date the most extensive amounts of vertebrate soft tissue have been recovered from placoderms where large blocks of muscles allow for the complete musculature of the neck and body to be determined. Metamerically segmented body musculature has also been recovered from a sole acahndrom species, a yet to be described chondrichthyan and actinopterygians. The extensive amount of muscle present from multiple taxa has enabled the evolutionary history of the vertebrate musculature to be determined. In addition to muscle preservation several taxu preserve organs, including the heart and liver, and the skin with its lateral line is preserved in the chondrichthyan and in tissue preservation also confirms the earliest evidence of live birth by the presence of a mineralized umbilical cord in a pycodont placoderm, the embryo still within the abdominal cavity of the adult. The presence of the umbilical cord indicates that these fishes were viviparous.

Soft tissue is not particularly decay resistant. The process of mineralization in the Gogo Formation appears to be the result of the combination of bacterial sulfate reduction and rapid burial in a low oxygen environment. Mineralization was rapid enough for high fidelity preservation of some of the muscle fibres, and some organ molecular breakdown on a very fine scale. These discoveries represent the oldest 3D preservation of vertebrate muscle and organs known to date.
Grant Information:
Australian Research Council DP11010127. Beam time ID19 proposal EC-203. ERC Advanced Investigator Grant 233111; Knut and Alice Wallenberg Foundation.

Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM)

NEW SKELETAL MATERIAL SHEDS LIGHT ON THE EVOLUTION AND PALEOBIOLOGY OF KOALAS

TSCHIRN, Amy C., Flinders University, Adelaide, Australia; CAMENS, Aaron B., Flinders University, Adelaide, Australia

Koalas (Marsupialia; Phascolarctidae) are a temporally and spatially widespread family represented by a single extant species, Australia’s largest arboreal folivore Phascolarctos cinereus. In contrast to the modern lack of diversity, fossil phascolarctids are speciose, with 17 species from 10 genera described from the last ~26 Ma. Previous paleobiological interpretations have been limited by a lack of postcranial material. Inferences based on craniodental material inferred that phascolarctids have occupied a sedentary, arboreal specialist niche throughout their evolutionary history. Here, we describe the limbs and tail of the first near-complete skeleton of an Oligo-Miocene (24 - 26 Ma) phascolarctid—Madoakaola devisi—from the Namba Formation, Lake Frome Basin, South Australia. Our dental analysis indicates that diagnostic characters of Madoakaola wellsi reflect ontogenetic, rather than taxonomic, differences from M. devisi and thus M. wellsi should be considered a junior synonym. To elucidate the functional capabilities of the taxon, we compare the skeletal morphology with extant marsupial species using convergent eco-morphological models. An analysis of post-cranial characters indicates that M. devisi was a highly mobile arboreal specialist with an elongate, semi-prehensile tail, similar in ecological niche and locomotory style to the extant possum, Pseudocheirus peregrinus. This novel interpretation differs markedly from previous inferences and demonstrates that the evolutionary history of phascolarctids is more complex than has previously been thought.

Grant Information:

Symposium: From Molecules to Macroevolution (Wednesday, October 9, 2019, 9:00 AM)

HOWE QUARRY (UPPER JURASSIC MORRISON FORMATION, WESTERN U.S.A.), A HOT SPOT FOR SAUROPOD SOFT TISSUE

TSCHOPP, Emanuel, American Museum of Natural History, New York, NY, United States of America; WIEMANN, Jasmina, Yale University, New Haven, CT, United States of America; DELA PIERRE, Francesco, Università di Torino, Turin, Italy; CAVAGNA, Simona, Università di Torino, Turin, Italy; NORELL, Mark A., American Museum of Natural History, New York, NY, United States of America

Sauropod soft tissue reports are restricted to a few occurrences of skin impressions associated with skeletal material and/or footprints, and a single occurrence of possible cartilage preservation. Here, we present numerous new soft tissue samples from Howe Quarry, a site from the Upper Jurassic Morrison Formation. Howe Quarry is among the few localities from where sauropod skin impressions in association with skeletal remains have been reported in the past. The skin impressions have two different morphologies, one forming relatively large hexagons, and a second one being composed of small, irregularly shaped bumps. These skin impressions are always covered with a dark layer. Additionally, pneumatic cavities within cervical vertebrae of diplodocid sauropods are lined with a reddish layer. We analyzed the micromorphology and chemical composition of these layers with a series of methodologies, including scanning electron microscopy (SEM), environmental SEM, energy dispersive x-ray spectroscopy (EDS), fluorescence microscopy, ultraviolet photography, decalcification, and raman spectroscopy (RS). The micromorphology of the dark layer on the skin impressions shows mostly smooth surfaces, but with areas marked by structures that have been interpreted as both bacterial mats and melanosomes in the past. EDS analysis shows high amounts of carbon and oxygen, confirming the organic origin of this layer. Skin samples react strongly to UV light and fluorescence microscopy, with a distinct reaction from adhesives, plaster, sediment, and bone. RS reveals the typical signal of melanosomes, indicating that some of the structures seen under the SEM might represent melanosomes. Decalcification of the reddish layer lining the pneumatic chamber resulted in the recovery of fragments of a membrane, likely representing the membrane of the air sac that occupied the pneumatic chamber. RS of these samples show a distinctive signal that is different from both the adjacent bone and sediment, and also lacks the eumelanin peak seen in the skin samples. Hence, Howe Quarry is not only an important site for its 20-25 partly articulated individual skeletons of sauropod dinosaurs, but also preserves an array of soft tissue that will help us understand the paleobiology of these animals in more detail.

Grant Information:
Division of Paleontology and Theodore Roosevelt Memorial Fund, American Museum of Natural History

Regular Poster Session I (Wednesday, October 9, 2019, 4:15 - 6:15 PM)

A NEW ORNITHOMIMID (THEROPODA, ORNITHOMIMOSAURIA) FROM THE UPPER CRETAEOUS NEMEGT FORMATION OF BUGIN TSAY, MONGOLIA

TSOGTBAATAR, Chinzorig, Institute of Paleontology and Geology, Mongolian Academy of Sciences, Ulaanbaatar, Mongolia; KOBAYASHI, Yoshitsugu, Hokkaido Univ, Hokkaido, Japan

The Upper Cretaceous Nemegt Formation (upper Campanian-lower Maastrichtian) of the Nemegt Basin of Mongolia is one of the most fossiliferous terrestrial rock units in Asia. Skeletal remains of ornithomimid dinosaurs are relatively abundant among other dinosaur taxa in this formation. The first ornithomimid, which is composed of three nearly complete skeletons, collected by the Polish-Mongolian Paleontological Expedition and Mongolian Paleontological Expedition between 1965 and 1967 from this formation is Gallimimus bullatus. Since then, two more definitive ornithomimosaurs, Anserimimus planinychus and Deinocheirus mirificus, have been described from the same formation so far. In the summer of 1995, the Japan-Mongolian Paleontological Expedition found a nearly complete articulated ornithomimid skeleton with a skull from the formation at Bugin Tsay locality, in the northwestern part of the Nemegt Basin of the Gobi Desert. Here we describe a complete skeleton of an ornithomimid specimen, which provides a great deal of anatomical information and disparities of ornithomimosaurs and helps us to understand interrelationships within ornithomimosaurs. This new specimen shows the following unique features: sharply recurved ungual I and straight unguals II and III, hump-like tubercle on the dorsal interrelationships within ornithomimosaurs. Differences in hand structure of this new taxon may show difference in its function from the other Nemegt ornithomimosaurs. The Nemegt ornithomimosaurs reveal wide variations in hand morphology, demonstrating these ornithomimosaurs could have co-existed by having niche partitioning.

Regular Poster Session III (Friday, October 11, 2019, 4:15 - 6:15 PM)

NEW SPECIMENS OF NYANZACHOERUS (MAMMALIA, ARTIODACTYLA, SUIDAE, TETRACONODONTINAE) FROM THE UPPER MIOCENE NAKALI FORMATION, KENYA

TSUBAMOTO, Takehisa, Ehime University, Matsuyama, Japan; KUNIMATSU, Yutaka, Ryukoku University, Kyoto, Japan; MANTHI, Fredrick K., National Museums of Kenya, Nairobi, Kenya; NAKATSUKASA, Masato, Kyoto University, Kyoto, Japan

The upper Miocene Nakali Formation (ca. 10 Ma) of central Kenya is one of the important localities of vertebrate fossils particularly in anthropology and paleontology because the formation has yielded several taxa of early hominins. Since 2002, a joint research team from Kyoto University of Japan and National Museums of Kenya has been conducting paleontological field research in the Nakali Formation and has collected many fossil specimens of mammals. Here, we report new gnathodental specimens of Nyanzachoerus (Mammalia, Artiodactyla, Suidae, Tetracodontinae) from the Upper Miocene Nakali Formation, Kenya.

Nyanzachoerus is characterized by a lower crown and relatively weaker forwrows of the molar and proportionally larger P3-P4 compared to M3 among the species of the genus, implying that it is morphologically most primitive among the genus and is assigned to a new species of the genus. It shows close morphological similarities of the dentition with a Pilocene Asian tetracodontid genus Sivachoerus, implying a possible closer phylectic relationship of Sivachoerus prior with the Nakali Nyanzachoerus rather than with Nyanzachoerus tulotos or Nyanzachoerus devansii. This phylectic relationship implies a possibility that S. prior diverged from a stock of the
Nakali Nyanzachoerus during the early late Miocene (Tortonian) in East Africa and then the lineage moved from East Africa to Asia. It stressed that there seem to be a problem of paraphyly of the genus Nyanzachoerus.

Grant Information: JSPS KAKENHI Grant Numbers 25257408 and 16H02757 to M. Nakatsukasa and 16K07534 (to T. Tsuubamoto).

Technical Session VII (Thursday, October 10, 2019, 8:30 AM)

ECOMORPHOLOGICAL AND ALLOMETRIC SIGNATURES IN ENDOCRANIAL SHAPE IN CROCODYLIANS

TURNER, Alan H., Stony Brook University, Stony Brook, NY, United States of America; WATANABE, Akinobu, NYIT College of Osteopathic Medicine, Old Westbury, NY, United States of America; BEYL, Alexander R., Stony Brook University, Sellsburg, IN, United States of America; D’AMORE, Anthony H., Smithtown High School East, Smithtown, NY, United States of America; WILBERG, Eric, Stony Brook University, East Setauket, NY, United States of America; SAMAERS, Jeroen H., Stony Brook University, Stony Brook, NY, United States of America; GIGNAC, Paul M., Oklahoma State University Center for Health Sciences, Tulsa, OK, United States of America

It is well established that ecological transitions are often associated with morphological transformations. The degree to which brain morphology keeps pace with other morphological changes is, however, less well established. Extant crocodylomorphs exhibit an impressive range of ecologies, spanning fully marine taxa to small herbivores and terrestrial predators across a wide body-size spectrum. This past ecological diversity stands in contrast to modern crocodylians, which are largely semi-aquatic ambush predators. Nevertheless, extinct crocodylians show preference for freshwater systems (Crocodylus johnstoni), whereas others (C. porosus) prefer coastal saltier waters, while still others prefer rainforest river systems (Mecistops and Osteolaemus) like their cousins the dwarf caiman or are extreme piscivores like Gavialis.

To explore how ecological preferences may be reflected in brain morphology, we used a high-density 3D morphometric approach on cranial endocasts of a broad sample of extant and extinct crocodylians. Endocranial shape broadly exhibits phylogenetic clustering where major clades occupy different, but overlapping regions of the morphospace. Combined with a time-calibrated phylogeny, we performed a suite of comparative phylogenetic analyses. Results indicate that allometry accounts for nearly a third of the endocranial shape variation after correcting for phylogenetic structure. Notably, habitat preference was associated with over half of the total variation in endocranial shape, particularly an enlarged medulla in more salt-tolerant taxa. This brain region is responsible for homeostatic functioning and may have been selected for in marine and marine-tolerant species. Our work indicates that ecomorphological changes extend to brain morphology, especially in regions relevant to functional demands of the environment. Stated another way, neuroanatomical shape has the potential to infer the ecological preferences of extinct vertebrates.

Grant Information:
National Science Foundation DEB grants 1754596 and 1754659.

Regular Poster Session I (Wednesday, October 9, 2019, 4:15 - 6:15 PM)

THE DENTITION AND SKELETON OF MOOREODONTUS: NEW INSIGHTS INTO THE ORIGIN AND DEVELOPMENT OF THE TRIASSIC XENACANTH SHARKS

TURNER, Susan, Queensland Museum, Brisbane, Australia; SOLER-GDON, Rodrigo, Museum fuer Naturkunde, Berlin, Germany; HESTER, Elf, Museum fuer Naturkunde, Berlin, Germany; MCCURRY, Matthew, Australian Museum, Sydney, Australia; AVERY, Steven, Australian Museum, Sydney, Australia

Triassic xenacanths are known from several Australian localities; the first recorded specimens, “Pleuracanthus” parvidens (ASW Woodward), came from the Middle Triassic Anissan Ashfield Shale (Wianamatta Group), Sydney Basin, New South Wales. The NSW material has been assigned to Mooreodontus, a genus based on isolated Upper Triassic (Carnian) teeth from England. Despite long-standing discussion about generic assignment of xenacanth species based on dental features, the Australian articulated material has never been studied in detail. We review the holotype of M. parvidens and describe additional new Anissian material from Picton (M. parvidens) and Somersby (juvenile/subadult individuals probably a new species).

Mooreodontus has distinct features: 1) lacks a dorsal fin spine in contrast to other xenacanth taxa from the stem Diplodoselachus to derived Triodus and Xenacanthus where the spine is present and develops early in ontogeny; 2) a prominent squamation, a shared feature with Diplodoselachus, Lebachacanthus and Triodus; 3) a single dorsal fin, starting behind the pectoral girdle, extends along the complete body in contrast to other xenacanth where a caudal fin is quite distinct from an elongated dorsal fin; 4) two anal fins are located in a posteriormost relative position at the level of the caudal vertebrae. Consequently, Mooreodontus differs from Triodus and Xenacanthus, where the anal fins are located close to the pelvic fins and the caudal fin is very well developed approaching a diphyceral morphology; 5) Heterodonty. The individual dental variation includes teeth with the diagnostic features of Mooreodontus (i.e., a drop-shaped, lingually pointed bases) and with a rounded lingual margin, which might also be attributed to the genera Triodus, Xenacanthus and Tikiodontus.

In conclusion, Mooreodontus is a specialised xenacanth with several dental and endoskeletal features that distinguish it from the Carboniferous to Permian xenacanths Triodus and Xenacanthus. The mosaic of dental features shown by the articulated specimens explains the wide morphological variability already seen in isolated Triassic teeth and the difficulties to distinguish the genera. Future detailed studies of the dentition of articulated Australian material will improve knowledge of the possible diagnostic dental features and allow a more appropriate taxonomic assignment of isolated teeth from Paleozoic localities (e.g., Coomabatta Fm. at the Parana Basin, Brazil) where Mooreodontus appears to be present together with other xenacanths.
**“BONE HUNTERS” PROJECT – AUSTRALASIAN WOMEN IN VERTEBRATE PALEONTOLOGY**

TURNER, Susan, Queensland Museum, Brisbane, Australia; BERTA, Annalisa, San Diego State Univ, San Diego, CA, United States of America

Women have been pioneers in vertebrate paleontology since the early 19th century to the present day, with an increasing presence in the last 50 years. Our research is creating a history that highlights the important roles and achievements they have overcome to gain degrees and employment. We are delving into their lives and examining work done. Women ‘bone hunters’ were scarcer in 19th to early 20th century Australasia but as in other continents were often ‘hidden’, as illustrators (Hobson) or unpaid research assistants (Longman). Gaining training and professional employment came slowly, firstly because PhDs were unattainable until post-WWII and there were few universities or museums with suitable mentors. Professor Dorothy Hill was one who published on vertebrate remains, especially from Queensland and despite this being outside her main research interests. In Australia, much work has been done by incoming researchers from elsewhere, some of whom came to stay – Vickers-Rich (ex U.S.A.), Howie-Warren, Turner (ex U.K.) (all long-standing SVP members) – and these in turn paved the way for later home-grown women to pursue careers in paleontology. Others changed direction: Joan Wiffen in New Zealand was a teacher until retirement allowed her to pursue ‘bone hunting’; Mary Wade moved across country when she gained a full-time museum job in Queensland. There are many stories like these of women making changes. We are currently developing an online interactive database of women in paleontology. This project is called ‘The Bone Hunters Project’, which is in turn consistent with recovery of the skeleton from a well-sorted geochemical regime(s) of the depositional environments in which they were sampled. Ongoing work this year – thanks to all who contributed.

**PROTEIN SEQUENCES**

ULLMANN, Paul V., Rowan University, Glassboro, NJ, United States of America; MACAULEY, Kyle, Rowan University, Glassboro, NJ, United States of America; ASH, Richard D., University of Maryland, College Park, MD, United States of America

In 2005, demineralization of a fragment of the femur of *Tyrannosaurus rex* specimen MOR 1125 revealed a new mode of soft tissue preservation which captivated the public and scientific community alike: bone cells and pliable tissues. Although similar cells and soft tissues have since been recovered from more than 50 other Mesozoic and Cenozoic bones, the taphonomic and geochemical history of acclaimed specimen MOR 1125 has been the subject of extensive study. Our analyses revealed this specimen to exhibit modest rare earth element composition and geochemical history of acclaimed specimen MOR 1125. Our analyses revealed this specimen to exhibit modest rare earth element composition and geochemical history of acclaimed specimen MOR 1125. The Field Museum of Natural History has worked in the Chronister Dinosaur Quarry in southeastern Missouri, U.S.A. for the past three seasons and collected over 80 specimens in 12 plaster field jackets. The quarry is a wet, clay-rich site in a wetland, and the deposits contain relatively rare endogenous materials, which is in turn consistent with recovery of the skeleton from a well-sorted geochemical regime(s) of the depositional environments in which they were sampled. Ongoing work this year – thanks to all who contributed.

**GEOCHEMICAL TAPHONOMY OF TYRANNOSAURUS REX MOR 1125, THE FIRST CRETACEOUS FOSSIL TO YIELD ENDOGENOUS PROTEIN SEQUENCES**

**PREPARATION OF WET VERTEBRATE FOSSILS: DEVISING STRATEGIES TO MITIGATE DAMAGE**

**GRANT INFORMATION:**

- Rowan University Seed Funding Program
- Technical Session XIII (Friday, October 11, 2019, 2:30 PM)
- **VARIATION IN AUSTRALIAN CRETACEOUS SAUROPTERYGIAN AND ICHTHYOPTERYGIAN POSTCRANIAL MATERIAL**

VAKIL, Vikram, University of Queensland, St Lucia, Australia

The lower level taxonomy of Early Cretaceous Australian marine reptile fossils is based mainly on skull morphology, but many specimens lack skulls. This research compared the morphology and morphometrics of vertebrae from previously undescribed and published specimens of plesiosaurs and ichthyosaurs from the Queensland and Richmond museums and from published sources outside Australia. Morphological analysis included variation in size, shape and structure of vertebral elements including centra, zygopophyses, diapophyses and neural spines as possible. Biometric analysis involved measurement of parameters such as height, width, and length of centra, width of zygopophyses, angle between diapophyses and centre of centrum, height of neural spine, height and width of neural canal and distance between the plesiosaur cervical foramen. Vertebral Length Index, Height Index and Breadth Index also were calculated. Patterns of vertebral morphometrics were found to be useful for distinguishing Australian ichthyosaur specimens and morphometric data adds a new criterion for evaluating ontogenetic stage. Vertebral data suggest that more than one taxon of Australian ichthyosaur may exist, complicating the status of the only currently recognised species, *Platypterygius audax*. Vertebral data also will be useful for distinguishing Australian plesiosaurs with the clearest distinction made at family level where a polymorphid was easily distinguished from all elasmosaurs in all plots. Australian elasmosaurs were distinguished readily from non-Australian elasmosaurs (from literature). However, it is less clear if analysed Australian elasmosaurs represent one or more taxa and further study is required. Regardless, the data suggest that Australian taxa may represent an endemic clade within the elasmosaurs, which is consistent with the restricted intracontinental Eromanga Sea. Patterns in vertebral morphometrics also were found to distinguish juvenile and adult *Styposaurus*. However, it is clear that vertebrate can be useful for taxonomy and assignment of Australian marine reptile remains even where skulls are lacking. However, additional work is required to combine analyses of skulls and associated vertebrae, where possible, and include more specimens to better define intraspecific and ontogenetic variability and test for any sexual dimorphism in both groups.

**PREPARATION OF WET VERTEBRATE FOSSILS: DEVISING STRATEGIES TO MITIGATE DAMAGE**

VAN BEEK, Constance J., The Field Museum, Chicago, IL, United States of America; SHINYA, Akiko, The Field Museum, Chicago, IL, United States of America

The Field Museum of Natural History has worked in the Chronister Dinosaur Site in southeastern Missouri, U.S.A. for the past three seasons and collected over 80 specimens in 12 plaster field jackets. The quarry is a wet, clay-rich site, 10% Acrosil WS24, was applied, and a large perforated plastic tarp was placed over the jacket over two months. Toilet paper infused with polyethylene glycol (PEG) was used to fill
desiccation cracks for stability. After the clay dried completely, the mechanical preparation began, and the fossil was consolidated with 10% Paraloid B72. The second field jacket containing forelimb elements had a rounded and smooth edge. It was left untouched for about a year, so the contents were allowed to completely dry before opening it. The shrinkage of the clay was apparent with a gap of $\frac{1}{16}$ inch away from the field jacket, but the contents uniformly shrank with only a few cracks. The forelimb elements showed very little distortion, but porous fossils were fragile; so frequent B72 application was required. The third field jacket of about 6 feet in length and a foot in width and depth contained semi-articulated caudal vertebrae. When the jacket was opened after four months, the contents were still moist and unsafe to prepare; so it was left to dry for an additional month. Several large cracks had formed, as the clay was constrained by the shape of the field jacket. The large fissures filled with PEG, and B72 was used for consolidation of exposed fossil material.

The preparation of three field jackets showed that a gradual drying method with frequent WS24 application was the most effective method. Cracks and desiccation cracks for stability. After the clay dried completely, the mechanical preparation began, and the fossil was consolidated with 10% Paraloid B72. The second field jacket containing forelimb elements had a rounded and smooth edge. It was left untouched for about a year, so the contents were allowed to completely dry before opening it. The shrinkage of the clay was apparent with a gap of $\frac{1}{16}$ inch away from the field jacket, but the contents uniformly shrank with only a few cracks. The forelimb elements showed very little distortion, but porous fossils were fragile; so frequent B72 application was required. The third field jacket of about 6 feet in length and a foot in width and depth contained semi-articulated caudal vertebrae. When the jacket was opened after four months, the contents were still moist and unsafe to prepare; so it was left to dry for an additional month. Several large cracks had formed, as the clay was constrained by the shape of the field jacket. The large fissures filled with PEG, and B72 was used for consolidation of exposed fossil material.

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RESOLVING THE TAXONOMIC VALIDITY OF THE GIANT EXTINCT MARSUPIAL NOTOTHERIUM (DIPROTODONTIDAE) AND ITS RELATIONSHIP TO ZYGOMATURUS

VAN ZOELEN, Jacob D., Flinders University, Adelaide, Australia; PRIDEAUX, GavJ., Flinders University, Adelaide, Australia

The megafaunal herbivores of the family Diprotodontidae were integral members of terrestrial ecosystems in Australia and New Guinea until the last-surviving and largest-ever diprotodontid, Diprotodon optatum, became extinct c. 40,000 years ago. Despite their iconic status as the largest-ever marsupials and the frequency with which their remains are encountered, key aspects of their life histories and evolutionary history remain poorly resolved. There is no clearer example of this than the taxonomic confusion surrounding the late Cenozoic genera Nototherium Owen, 1845 and Zygomaturs Macleay, 1858, which has persisted for more than 160 years. This is attributable to: 1) the highly fragmentary fossil material upon which the original two species of Nototherium were founded; 2) the destruction of the lectotype of N. inerme during World War II; and 3) marked similarities in the size and shape of the jaws and teeth of species referred to Nototherium and Zygomaturs. More recently, this has led to Nototherium and its original two species, N. inerme and N. michelli, being relegated to nomina dubia. However, re-appraisal of the type material plus new material recently uncovered, including two crania, has shed light on the taxonomy and distinctiveness of Nototherium and provided evidence for its validity. Here I reassess the systematics and distribution of Nototherium and Zygomaturs and provide a preliminary diagnosis of the two most convergent and oft-confused species, Nototherium inermic/michelli and Zygomaturs trilobus.

Grant Information:
Royal Society of South Australia
College of Science and Engineering Flinders University
University of California Museum of Paleontology

THE RICH ICHNOLOGIC RECORD OF EGG MOUNTAIN FROM THE TWO MEDICINE FORMATION (UPPER CRETACEOUS) OF MONTANA, U.S.A.: PROVIDES INSIGHT INTO ENVIRONMENT, SEDIMENTOLOGY AND ECOLOGY OF A DINOSAUR NESTING SITE

VARRICCHIO, David J., Montana State Univ, Bozeman, MT, United States of America

The Upper Cretaceous Egg Mountain locality is a rich dinosaur nesting site that famously produced the first dinosaur eggs from North America and multiple clutches for the theropod Troodon formosus. Recently, the site has produced several well-preserved mammals and lizards. In addition to abundant skeletal and egg remains, several kinds of trace fossils indicate abundant biological activity, representing nesting, dwelling, and feeding behaviors. We report the first comprehensive overview of trace fossils from the site. Reproductive traces of both vertebrates and invertebrates are pervasive. Eggs and eggshell represent five different oviparous vertebrates that bury or partially bury their eggs within the substrate. These include eggs for the dinosaurs Troodon, Maiasaura, and the ootaxon Continoolithus, as well two thin, un-ornamented varieties of eggs of unknown identity. Insect predation structures are abundant throughout the less than 3 m section and suggest workable, well-drained soil conditions consistent with relatively low sedimentation rates throughout the time of deposition. Their abundance correlates semi-annual, seasonally dry conditions of the Two Medicine Formation and may indicate relatively sparse vegetation. Furthermore, enigmatic hemispherical structures may represent invertebrate dwelling and feeding traces and add to the diversity of burrowing soil organisms at the locality. Vertebrate feeding traces are represented by three morphologies of coprolites and multi-individual, crania-skewed assemblages of small vertebrates (mammals and lizards) that may represent regurgitated gastric pellets and/or prey-processing locales. Though the specific producers of these feeding traces are difficult to determine, they offer unique insight into trophic interactions at the locality. Overall, the strong abundance of trace fossils suggests a suitable environment for both soil-dwelling organisms and nesting vertebrates. Large, well-preserved bones are notably absent from the site. The trace fossil assemblage is dominated by in situ terrestrial activity with the majority of the invertebrate (coprolite) and vertebrate (nesting activity) traces representing subsurface activity. The record of biotic activity is a unique window into the ecology and environment of a Cretaceous dinosaur nesting locality.

Grant Information:
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NEW DATA ON THE NEOGENE MARINE MAMMAL FAUNAS OF THE EASTERN NORTH PACIFIC

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Marine sedimentary deposits from the eastern North Pacific region provide us with a nearly continuous record spanning the last 30+ million years. Some of the major transition in the evolutionary history of marine mammals are recorded within these deposits and allow us to look at the timing of these events at different scales. Herein we reviewed published observations and add new data of Miocene-Pliocene marine mammals based mainly on the NIMLA and OCPC collections. Our data includes specimens from formations spanning from Washington to Baja California Sur. Occurrences are plotted on a site-by-site basis, with updated chronostratigraphic and taxonomic information, allowing for more precise first and last appearance dates. Preliminarily, some of the patterns observed hint at major changes around the mid Tortonian (~9-8 Ma) as follows. Platanistoids, present in the region since the Oligocene, disappeared ~9 Ma, roughly coinciding with the first appearance of lipotids in the late Tortonian (~8 Ma). Kentriodontids are restricted to Aquitanian to early Tortonian deposits, contrasting with Western Atlantic faunas where they persist until the Pliocene. Crown group delphinoids appear by the late Tortonian and are still present, with some (e.g., monodontids) now restricted to the Arctic. Pinnipeds assemblages shift from those comprised of desmatophocids, stem otariids, and basal odobenids during the Burdigalian through Langhian to those dominated by large odobenids, including the appearance of neodobenians. Herbivorous marine mammals are present in Burdigalian-Langhian deposits, including multi-species communities of desmostylians and dugongs. However, by the late Serravalian through early Tortonian, herbivore diversity declines with the local extinction of dugongines and desmostylians, after which hydrodamalines remain.

Our data hints at major faunal changes around the mid-late Tortonian (~9-8 Ma), including the local extinction of some odontocetes, desmatophocids, and desmostylians, and the evolution and diversification of several modern groups such as delphinoids and neodobenians. The appearance and predominance of benthic-feeding taxa, and kelp-eating sirenians by the late Miocene can be correlated with increasing upwelling along the eastern North Pacific which led to changes in benthic productivity and the evolution of large, fast growing algae. Ongoing work aimed at narrowing the chronostratigraphic range of poorly constrained formations in California and Mexico will allow us to improve upon these observations.

Evolutionary trends of protopothyrid lineage through Miocene-Pliocene of South America

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Protopothyrids (Interatheriinae, Notoungulata, Mammalia) is a well-known and very diverse genus of extinct native ungulates of South America, widely distributed from southern to middle latitudes of Argentina, Chile, and Bolivia. This genus exhibits distinctive species throughout the different bioregions from the Miocene to Pliocene which display an interesting size pattern. Three species of Naquetia from the late Early Miocene, P. attenuatum (small), P. praerutilum (medium), and P. australis (large), two species from the Middle to early Late Miocene, P. endiades (small) and P. colonicuvus (large), two species from the Late Miocene, P. mitatum (small) and P. distinctum (large), and only one species from Late Miocene-Pliocene, P. antiquum (large). The large sample of specimens studied during several years of research allow to us to analyze the shape and size of upper and lower molars for all the species of Protopothyrid. In order to test the hypothesis of reduction of size ranges preserving a general tooth morphology as a response to climate deterioration. Elliptic Fourier analyses (EFA) were used to capture the shape of the occlusal
morphology and the centroid size (CS) was also retained for subsequent analyses. One can demonstrate that: (1) in general, a similar morphological tooth pattern is observed among all species from Miocene to Pliocene; (2) there is a tendency to increase the size from the smallest species of the late Early Miocene (e.g., P. australis) to the largest one in the Late Miocene-Pliocene (P. antiquum); (3) tooth shape variation is not associated with a change in size (CS), both in upper and lower molars and between small and large species; (4) a decrease in the number of species is recorded from three in the early Miocene to one in the Late Miocene-Pliocene. This striking pattern could be correlated with a general global trend to lower temperatures, which indicates a deterioration of paleoenvironmental conditions. In South America, a markedly descend of temperature occurred during Miocene times that is also testified by paleoflora and the marine environmental. Given this paleoenvironmental context, a successful conservative tooth pattern, together with an increase in size and a reduction in number of species were the main evolutionary and ecological tendencies accounted in Protophytium from the Miocene to Pliocene.

Technical Session XIII (Friday, October 11, 2019, 3:00 PM)

PATTERNS OF OSSIFICATION IN THE VERTEBRAL COLUMN OF ANNIOIDES AND THEIR ANCESTRAL CONDITION

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Ossification in the axial skeleton of annioides displays a great diversity with regards to relative timing and overall patterns. Unfortunately, due to the infrequent preservation of ontogenetic sequences in the fossil record and limited research interest, the evolutionary history of these patterns remains poorly understood. Thanks to several exceptionally well-preserved specimens of the early Permian mesosaurus sauropsid Stereosternum tumidum, we were able to observe mineralization gradients along the spine and retrace the ossification sequences of several vertebral elements. In this study, we focused our attention on four major traits for which we reviewed the state of knowledge in annioides and performed ancestral state reconstructions: (1) the number of loci from which neural arch ossify, (2) the number of loci from which centra ossify, (3) the number of loci and direction of neural arch fusion, and (4) the spreading direction of neurocentral suture fusion. For all examined traits, it appears that the condition in Stereosternum represents the plesiomorphic state not only for sauropsids but for annioides in general. Neural arch and centra ossification first occur in one locus in the anterior cervical region and progress posteriorly along the spine. Similarly, fusion of initially paired neural arch elements first occurs in the anteriormost cervicals and then follows a “zipper-like” cranio-caudal gradient. Conversely, closure of the neurocentral suture begins in the last caudal vertebrae and then proceeds anteriorly from that point. These patterns seem to constitute a major difference between the sauropsid and the synapsid lineages, the latter being more diverse with regards to the number of loci and direction of ossifications. Modes of neurocentral suture closure appear to vary substantially within the sauropsid lineage, with marked differences between major clades, suggesting that these characters may bear more phylogenetic signal than previously realised. However, further research is necessary to refine our more detailed and deep-time understanding of the evolutionary history of these traits.

Grant Information:
German Research Foundation DFG (Project 372767665)
Technical Session VIII (Thursday, October 10, 2019, 3:00 PM)

A 3D GEOMETRIC MORPHOMETRIC ASSESSMENT OF INTERPOPULATIONAL CRANIAL VARIATION IN THE MARSUPIAL DASYURUS HALLUCATUS

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The morphological identification of mammalian species can be challenging when there is substantial intraspecific diversity in the paleontological record. Finding the morphological patterns that lead to intraspecific differentiation can be a useful tool to address this issue. Here, we use the extant Northern quoll as an ideal species for testing if, and how, local adaptation to ecologically distinct environments can lead to divergence in cranial shape between genetically close relatives. The Northern quoll used to be distributed throughout a large part of northern Australia. However, its distribution is now fragmented into genetically distinct, isolated populations separated by major biogeographic breaks, which may have begun to partition their range well before the first records from the European settlement. Despite this relatively short time of isolation, fast phenotypic adaptation is expected due to the short life span of this species. Here, we use 3D geometric morphometrics to quantify the full 3D cranial shape variation of 181 Northern quoll individuals belonging to four mainland populations and several island populations. 900 landmarks were used in this study, including 101 fixed landmarks, 93 curves and 18 patches. Procrustes ANOVA suggests significant interpopulation shape differences. Cluster analysis also reveals that these correspond to genetics-based phylogenies. Pairwise comparisons between the mean shapes of each population showed longer skulls with shorter muzzles for Queensland and Northern Territory populations, a more prominent braincase and wider muzzles for Kimberley and Pilbara populations, and smaller skulls and shorter muzzles for island populations. However, potential confounding factors include allometry, sexual dimorphism, a geographical continuum and precipitation ranges. We demonstrated a possible link to precipitation data and a longitudinal continuum, Pilbara desert individuals present acoustic-adapted basicranium shape relative to rainforest individuals with larger skulls possibly adapted to interspecific competition and a high-resource diet. For paleontological and biogeographical studies concerned with closely related species, our results indicate that interpopulation variation is confounded by ecological drivers and can be masked at the species differentiation level. Furthermore, the template used in this study has the potential to be applied to several mammalian taxa, allowing investigations of how these processes occur across the micro and macroevolutionary level divide.

Grant Information:
This study would have not been possible without The UQ International Research Scholarship granted to PV and the ARC Discovery Grant DP170103227 awarded to VW.

Technical Session XI (Friday, October 11, 2019, 8:00 AM)

DO RAPTOR PELLETS RECORD SMALL MAMMAL COMMUNITY COMPOSITION OR RAPTOR DIETARY PREFERENCE? A CASE STUDY IN YELLOWSTONE NATIONAL PARK

VITERI, Maria, Stanford University, Stanford, CA, United States of America; STEGNER, Mary Allison, Stanford University, Stanford, CA, United States of America; HADLY, Elizabeth A., Stanford University, Stanford, CA, United States of America

Skeletal remains from raptor pellets have long been used to reconstruct small mammal communities, yet pellets are also commonly cited as proxies for raptor dietary preferences. While past research has shown that certain species of raptors, such as barn owls, sample local small mammal communities in proportion to their true local abundances, few studies have been conducted across multiple raptor species. This is important for understanding taphonomic biases both in modern pellet assemblages and in deeper-time accumulations of bone where raptors served as the sampling vector, as in many cave deposits.

We examined nearly 1000 pellets from seven species of avian predators including ravens and both nocturnal and diurnal raptors that were collected in the late 1990s from four localities in Yellowstone National Park, Wyoming, U.S.A. The localities differ in habitat type, vegetation structure, and climate, and therefore exhibit differences in their small mammal communities. We ask: Across these sites, do raptors differ from one another in their prey preference, or do they eat what is locally abundant? If raptor species have strong dietary preferences, we expect to find similar diets within species, across localities. If instead they eat what is locally abundant, we expect that different raptor species at the same site will have more similar diets, but their diets will differ significantly between sites.

We morphologically identified craniodental material from pellets and quantified relative abundance from the number of individual specimens. We visualized differences in small mammal prey among sites and among predator species using principal components analysis and tested for differences. Preliminary analyses show that while each raptor species does tend to eat similar subsamples of the small mammal community, most variation in raptor diet is explained by locality. These results suggest that raptors faithfully sample their local small mammal communities and exhibit optimal foraging instead of dietary specialization. Analysis of raptor pellets remains a promising method for accurately and non-invasively sampling past and modern small mammal communities.

Grant Information:
NSF GRFP

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CHARACTERIZING THE ONTOGENETIC STAGE OF A VERY LARGE SPECIMEN OF ALLOSOURUS FROM THE JURASSIC OF WYOMING WITH SUBADULT CHARACTERISTICS

VODEGELE, Kristyn K., Rowan University, Glassboro, NJ, United States of America; ULLMANN, Paul V., Rowan University, Glassboro, NJ, United States of America; GROVE, Joseph, Concordia College, Moorhead, MN, United States of America; NELLERMOE, Ron, Concordia College, Moorhead, MN, United States of America

A previously undescribed, isolated specimen of Allosaurus was discovered associated in 2004 in north-central Wyoming in the Jurassic Morrison Formation. Comprised of 65 cranial and postcranial elements, this specimen exhibits a unique combination of large body size with subadult characteristics. The majority of the dorsal vertebrae remain unfused, the pubes remain unfused, the coccyx is unarticulated, the alveoli in the dentary and maxilla are not fully erupted, and the femoral head remains separated from the femoral shaft. A careful analysis of the fossil indicates that this specimen is an Allosaurus individual, with a femoral midshaft circumference of 28 cm. To reconcile the discrepancy between its size and features commonly associated with adult individuals, we have completed a histological analysis of the only limb bone preserved, the partial right femur. As we have found no evidence of epiphyseal lines of arrested growth on the preserved portion, we conclude that this specimen is an Allosaurus individual, with a femoral midshaft circumference of 28 cm. To reconcile the discrepancy between its size and features commonly associated with adult individuals, we have completed a histological analysis of the only limb bone preserved, the partial right femur. As we have found no evidence of epiphyseal lines of arrested growth on the preserved portion, we conclude that this specimen is an Allosaurus individual, with a femoral midshaft circumference of 28 cm. To reconcile the discrepancy between its size and features commonly associated with adult individuals, we have completed a histological analysis of the only limb bone preserved, the partial right femur. As we have found no evidence of epiphyseal lines of arrested growth on the preserved portion, we conclude that this specimen is an Allosaurus individual, with a femoral midshaft circumference of 28 cm. To reconcile the discrepancy between its size and features commonly associated with adult individuals, we have completed a histological analysis of the only limb bone preserved, the partial right femur. As we have found no evidence of epiphyseal lines of arrested growth on the preserved portion, we conclude that this specimen is an Allosaurus individual, with a femoral midshaft circumference of 28 cm. To reconcile the discrepancy between its size and features commonly associated with adult individuals, we have completed a histological analysis of the only limb bone preserved, the partial right femur. As we have found no evidence of epiphyseal lines of arrested growth on the preserved portion, we conclude that this specimen is an Allosaurus individual, with a femoral midshaft circumference of 28 cm. To reconcile the discrepancy between its size and features commonly associated with adult individuals, we have completed a histological analysis of the only limb bone preserved, the partial right femur. As we have found no evidence of epiphyseal lines of arrested growth on the preserved portion, we conclude that this specimen is an Allosaurus individual, with a femoral midshaft circumference of 28 cm.

With accumulating fossil evidence over the last two decades, the evolutionary history of early mammals has become increasingly well documented. As more and more fossils are recovered, our understanding of the diversity and evolution of early mammals has expanded. In this presentation, we will discuss recent discoveries of early mammals from the Late Cretaceous of western Liaoning and the surrounding region in northeastern China. These include the early-diverging avialans Jeholornithiformes, Confuciusornithiformes, Sapeornithiformes, and Jingufortisidae. Here we report on a new avialan specimen consisting of a nearly complete skeleton with carbonized feather traces from the Jehol Group near Jianchang. The new specimen is intermediate in size between confuciusornithiforms and sapeornithiforms; however, it is inferred to be a not-fully-grown individual based on histological features and the degree of skeletal fusion. Several unique features differentiate it from other early-diverging avialans, including an extremely short bony tail consisting of at most four free caudal vertebrae and a short pygostyle (about 40% the length of metatarsal III), a short scapula (about 70% of the acromial length), an ilium with a small pubic peduncle (also present in scansoriopterygid theropods), a long pedal digit IV (subequal to pedal digit III), and most notably a pair of short bony crests on the nasals. Cladistic analysis places this new specimen within the Pygostyidae, sister to all other pygostylians, thought it has a few striking plesiomorphic features such as a large maxillary fenestra, a maximum of five sacral vertebrae and an incomplete rib. The new avialan closely resembles jeholornithiforms in numerous aspects of its cranial, dental, pelvic, and hindlimb morphology, but is also similar to confuciusornithiforms in having a wide furcula with an interclavicular angle greater than 90 degrees, a large fenestra perforating the humeral deltopectoral crest (also present in confuciusornithiforms), a further shortened alular digit (the distal extension of the digit about the level of the distal end of the major metacarpal; also present in jeholornithiforms and jingufortisidae), a reduced manus digit (also present in jingufortisidae), and the absence of an ossified sternum and uncinate processes. In addition, the new specimen shares with confuciusornithiforms and jingufortisidae a
significantly thickened proximal phalans of the major digit. This discovery fills a morphological gap between early-diverging clades of avians, as well as documents a previously unknown morphology - the presence of bony nasal crests, thus contributing important new information pertaining to early avian evolution.

Grant Information:
National Natural Science Foundation of China(Grant No. 41688103), the Strategic Priority Research Program of the Chinese Academy of Sciences (Grant No. XDB18030504)

Technical Session XVII (Saturday, October 12, 2019, 10:45 AM)

**MORPHOGENESIS OF EXTANT FEATHER RACHIS HELPS CLARIFY THE VARIATIONS OF MESOZOIC FEATHERS**

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Modern feather rachises, composed of a dense external cortex and spongy internal medulla, are flexible, yet stiff enough so the body surface can be streamlined and able to withstand large aerodynamic forces encountered during flight. The lack of knowledge about rachidal morphology in early feathers prevents an understanding of how this complex architecture evolved. This has led to controversy in understanding the early evolution of bird flight. Feather morphotypes previously unknown in extant birds, called “rachis-dominated feathers” (RDFs) have been reported in several lineages of non-avian and avian theropods. A recent study demonstrated that these feathers consist of only the rachidial dorsal cortex, which challenges the existing models depicting the early evolution of feathers and raise the question of how these rachidial morphotypes have evolved. We show the rachidal dorsal cortex, rachidial ridge, medulla and ventral cortex are formed sequentially in extant birds and demonstrate that diverse Mesozoic feathers documented in fossil records are not distinct feather morphotypes. Instead, they represent feathers with limited differentiation and/or keratinization of the posterior half of the cylindrical rachis. These feathers with rachises consisting only of the dorsal cortex are not as strong as those with a cylindrical rachis and may have played limited aerodynamic functions.

Grant Information:
This work is supported by the NSFC (41602013), the HSF(LT000728(2018)), and the NIH (AR47364, AR60306).

Technical Session I (Wednesday, October 9, 2019, 8:00 AM)

**NEW COMPLETE SKELETON OF PSPHOCHELYS POLYOSTEODERMA (SAUROPTERYgia: PLACODONTiA) WITH A DEVELOPING CARAPACE**

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Triassic sauropotypians include a group of armored marine reptiles called placodonts, some of them even develop complete carapaces superficially similar to turtle shells. Compared with other Triassic marine reptiles, placodont fossil remains are relatively rare, restrictively distributing in Europe, the Middle East, and southwestern China. Our knowledge of preliminarily reported Chinese placodont taxa and their carapacial development is still limited. Here we describe a new complete skeleton of placodonts from China, revealing not only more anatomical details of this placodont genus, but also the fusion pattern of the placodont carapace. This new material can be confidently referred to *Pspohchoselys polyosteoderma*, mainly based on its narrow, spatulate and edentulous rostrum, the carapace composed of small and numerous armor plates with the relatively smooth surface. Therefore, it represents the first known subadult individual as well as the most complete specimen of *Pspohchoselys*, and further confirms more diagnosis, such as transverse processes of dorsal vertebrae not anteroposteriorly expanded, two ossified tarsals, the phalangeal formula in the pes of 1-2-3-4-2, etc. The phylogeny of placodont, the family Placochelyidae in particular, is revised by employing an updated character matrix. A better-resolved result demonstrates that *Pspohchoselys* is a derived taxon in Placochelyidae instead of a basal member as previously obtained, and *Macroplacus* is most possibly a derived member in Placochelyidae too. Interestingly, compared with the adult type specimen, the incompletely developed carapace in this new skeleton suggests that the ossification starts in the axial region covering the vertebral column and the marginal regions contouring the shell, then the lateral walls are thickened, and after that, more armor plates are generated to fill the gaps between the axial and marginal regions. This fusion pattern superficially resembles the ontogenetic process of the shell in turtle embryo, possibly implying the potential deep homology from their common ancestor.

Grant Information:
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Regular Poster Session I (Wednesday, October 9, 2019, 4:15 - 6:15 PM)

**NEW DATA OF THE PALEOGENE STRATIGRAPHY AND MAMMALIAN PALEONTOLOGY IN THE ERLIAN BASIN, INNER MONGOLIA, CHINA AND ITS IMPLICATIONS TO THE ASIAN PALEOGENE BIOCHRONOLOGY**

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The well-known Erlian Basin in Inner Mongolia, China has played an important role in establishing the Paleogene Asian Land Mammal Ages (ALMAs). Four ALMAs, including Arshantan, Iringhanian, Sharamurunian, and Ulangochuanian, were proposed on the basis of mammalian faunas known from the basin. However, the existence of some long-standing basic stratigraphic problems has hampered the understanding of the faunal composition and the recognition of the boundaries between those ages. Moreover, those boundaries are not well-constrained in age. The investigations to the Paleogene in the Erlian Basin in over a decade have clarified some basic stratigraphic confusions. According to the preliminary result of recent investigations, the terrestrial Paleogene in the Erlian Basin comprises seven formations, the Nomogen Fm, the Ashanto Fm, the Irdin Manha Fm, the Shara Murun Fm, the Ulan Gochu Fm, the Xianaoangangdi Fm, and the Shangaangoangdi Fm in ascending order, corresponding to the late Paleocene Gachatan through early Oligocene Hsandaogulian ALMAs. Preliminary result of mammalian biostratigraphical and magnetostratigraphic studies provide some reliable evidence for the temporary age constraint and the correlation of ALMAs with North American Land Mammal Ages (NALMAs). The Gachatan ALMA, represented by the mammalian fauna from the lower part of the Nomogen Formation, ranges from the transition of either of the Chrons C26n-C22r to the lower part of C22r, and can be correlated with the late Tiffanian (T15) to Clarkforkian NALMA. The Bumbarian ALMA, including mammals from the upper part of the Nomogen Formation, covers from the upper part of C24r to the lower part of C23r, and is correlated to Wasatchian NALMA. The Arshantan ALMA, represented by mammals from the Arshanto Formation, spans from the mid-C23r through the lower part of C20r, and is likely correlated to North American Bridgerian and lower Uinion (U1). The Iringhanian ALMA covers from the middle part of C20r to the lower part of C19r, and can be correlated to the middle part and the lower upper part of Uinion NALMA. The Sharamurunian ALMA covers the most C19r through the basal C18n, and is correlative to the most part of upper Uinion (U13) NALMA. The Ulangochuanian ALMA ranges from the lower C18n to the upper part of C17n, and can be roughly correlated to North American Duchesnean.

Grant Information:
Natl Nat Sci Foundation of China (41572021, 41572013), Strategic Priority Res Prog (B) of CAS (XDB26000000), Major Basic Research Projects of MST of China (2012CB821900)

Technical Session III (Wednesday, October 9, 2019, 2:15 PM)

**FUNCTIONAL MORPHOLOGY OF WAALEO POSTCRANIA FROM THE MIDDLE TO LATE MIOCENE OF CENTRAL AUSTRALIA REVEALS NEW INSIGHTS IN THE EVOLUTION OF MARSUPIAL HYPERCARNIVORES**

WARBURTON, Natalie M., Murdoch University Western Australia, Murdoch, Australia; YATES, Adam, Museum of Central Australia, Alice Springs, Australia
The extinct marsupial lions *Thylacoleo* spp. (*Marsupialia, Thylacoidei*) were apex predators of the Australian Pleistocene and Pliocene. Older thylacoideoids, however, are rare in the fossil record and the interpretations of the ecology of the ancestors of *Thylacoidea* have been built upon a small number of (often) fragmentary fossils. The genus *Wakaleo* is considered to be the plesiomorphic sister-group to *Thylacoidea*, and the two genera differ significantly in cranial form, dental formula, tympanic wing structure and frontal-squamosal contact. While early species of *Wakaleo* were likely arboreal, or at least scarpal, the ecology of later *Wakaleo* spp. is not well understood. Here we present descriptions of new postcranial material of from the Australian Northern Territory. *Wakaleo* vanderlueri from mid-Miocene Bullock Creek Northern Territory (NT) and *W. alcootaensis* from the late Miocene Alcoota Local Fauna NT, the youngest species of *Wakaleo*. Our calculations suggest that these taxa were smaller than previous thought, around 25kg and 50kg respectively. The postcrania reveal increasing adaptations towards terrestrial locomotion and felid-like grasping predation within this lineage. Such patterns are in contrast to the more canid-like adaptations occurring in the other major group of terrestrial marsupial carnivores at the time, the Thylacoids. This hypothesis seems to reflect similar patterns of divergent morphological adaption for grasping versus pursuit hunting behaviors in large carnivorous forms among placental mammals, and highlights a greater diversity in the evolutionary history of medium to large sized marsupial carnivores during the Miocene in Australia than previously recognized.

Preparers’ Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)

SIEVING WITHOUT TEARS. THE FIRST 40 YEARS OF AUTOMATED SEDIMENT SCREENING FOR MICROVERTEBRATES


When collecting microvertebrates, a major challenge is to extract the fossil from the sediment with a minimum of physical effort and damage to the specimens. The traditional method with poorly consolidated sediment involves drying the sample, then soaking it in water to disaggregate it, then hand sieving the sludge in water. A refinement of this technique is to soak the sample in a sieve box, generally a high-sided tray with a mesh base, prior to sieving. Neither of these methods, however, solve the basic problem of being labour-intensive and destructive. This was partially solved by European mammal workers in the 1960’s who used bulky static sieves and a power pump to bulk process large volumes of sediment in the field. This method can be very effective but is labor-intensive. The disadvantages include the weight of the equipment and problems of transporting the pump, sieves, hoses *et al.* to the site. However, an advantage is that the residue is prepared in the field and available for immediate sorting. It was a small step to encase the static sieve in a 330-litre polythene tank and against the mesh nor clasts within the sediment. Specimens detached from their sediment drop to the bottom of the sieve and congregate in an area not washed by the sprinklers. The water is then not damaged by prolonged abrasion against the mesh nor clasts within the sediment.

Originally this machine was developed to wash dried sediments. However, it coped quite adequately with wet clay but at a much slower rate. Dried clay can be processed at a rate of 10-15kg/hour, compared with about 50kg/hour with a hand sieve. Wet clay is processed at about 1-2kg/hour. The slowness of the wet process is more than offset by the energy saved by not having to dry the clay and that plant material may be recovered intact. Functioning 24/7, it is feasible to wash large amounts of poorly fossiliferous sediments. The water can be recycled after passing through settling tanks. This machine can be used in the field, with a gasolene water pump or in the laboratory using a domestic water supply. Whether the sediment is processed wet or dry, there are considerably fewer breakages compared to hand sieving. Our machine is 40 years old this year and still functions.

Technical Session XVIII (Saturday, October 12, 2019, 2:15 PM)

EXCEPTIONALLY PRESERVED SKELETONS FROM THE LATE CAMPAIGN OF MONTANA PROVIDE A UNIQUE GLIMPSE INTO THE PALEOBIOLOGY OF MULTITUBERCULATES

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Multituberculates were among the most taxonomically diverse and numerically abundant mammals in Late Cretaceous terrestrial faunas of the northern hemisphere. In North America, they are known almost exclusively from isolated teeth and a handful of jaws, whereas the few associated skeletons of Late Cretaceous multituberculates are known from Mongolia, China, and Romania. Here we report on exceptional new multituberculate specimens, which we provisionally refer to *Cimexomyx judithae*, from the late Campanian-age (ca. 75.5 Ma) Egg Mountain locality of the Two Medicine Formation in western Montana, U.S.A.. The multituberculate remains at Egg Mountain consist of monospecific, multi-individual aggregates of semi-articulated craniodental and postcranial elements. In one instance, five individuals are preserved within <1 m², represented by five partial skulls with associated lower jaws, two partial pectoral girdles with one articulated forelimb, two articulated pelvic girdles and partially articulated hind limbs, and numerous semi-articulated to disarticulated postcranial remains in association. Both adult and subadult individuals occur in these aggregates; adult specimens exhibit fused distal epiphyses, fused cranial sutures, and heavily worn cheek teeth, whereas subadults exhibit unerupted incisors, emerging premolars, unfused distal epiphyses, unfused cranial sutures, and unworn cheek teeth.

In addition to providing a wealth of new morphological data, these specimens offer a glimpse into the behavior of *Cimexomyx judithae*. The presence of multiple well-preserved individuals of varying ontogenetic stages, to the exclusion of any other vertebrate taxa, suggests that these animals aggregated in life and died in close proximity to one another. The sedimentology and diverse invertebrate ichnology of Egg Mountain indicate that the locality was strictly terrestrial; thus, these animals may have come together in either an above-ground nest or a burrow. Evidence for low rates of sedimentation with extensive bioturbation, coupled with postcranial features in *C. judithae* that suggest burrowing capabilities, lend some support to the latter hypothesis. Taken together, these new specimens provide an unprecedented look at the paleobiology of multituberculates during the Late Cretaceous in North America.

Grant Information:

NSF #1325365 EAR (GPW & DJV)

NSF-GRF (LWN)

Regular Poster Session I (Wednesday, October 9, 2019, 4:15 - 6:15 PM)

TRACE ELEMENTS OF TERRESTRIAL SURFACE WATERS AND BONE DIAGENESIS: A LEARNING CURVE

WEBB, Gregory E., The University of Queensland, St. Lucia, Australia; FERGUSON, Kyle J., The University of Queensland, St. Lucia, Australia; CHAGAS, Anderson A., The University of Queensland, St. Lucia, Australia; VAKIL, Vikram N., The University of Queensland, St. Lucia, Australia; PRICE, Gilbert J., The University of Queensland, Brisbane, Australia; BURNE, Robert V., The University of Queensland, St. Lucia, Australia

The trace element history of fossil bone preserves evidence of environments where organisms lived (e.g., elements/isotopes incorporated during life), the age of samples (e.g., U-series dating), and the environments in which they were fossilised (e.g., secondary elements such as rare earth elements – REEs). Fundamentally, a specimen’s diagenetic history must be known in order to interpret critical data, as elements taken up in life (e.g., Sr) can be overprinted by secondary uptake or preferentially leached during diagenesis. Elemental source and mobility during fossilization depend in part on the water chemistry in the environment where fossilization occurs. REEs are particularly useful in understanding water bodies as the: 1) are a self-referencing set of elements not very prone to random variation; 2) their behaviour varies systematically with redox, alkalinity, source and transport pathways; and 3) their concentration in living tissue means that, in bone, they almost entirely represent secondary uptake in the environment of fossilization. Here we demonstrate the application of REE analysis in the interpretation of selected fossils, ranging from Pleistocene vertebrates through to Cretaceous dinosaurs. In analysing Sr isotope ratios in a *Diprotodon inconsider* (giant Pleistocene marsupial), secondary uptake of Sr from local basaltic soil at the site of burial.
was quantified by the correlation of associated positive Eu anomalies with lower (baselomic) Sr isotopic ratios and higher Sr concentrations. This allowed the original (life-derived) periodic Sr isotope fluctuations in the tooth to indicate seasonal two-way migration for Diprotodon. REE analysis of rodent bones aided understanding of paleoclimate by differentiating arid late Paleocene and humid Holocene conditions in a cave environment. Humid Holocene conditions with high organic matter allowed increased uptake of redox-sensitive Ce, but little U, from anoxic groundwater. Earlier arid settings with well oxygenated groundwater yielded low Ce, but high U, uptake. However, some problems remain unresolved. Dinosaur bones preserved in carbonate concretions in the Cretaceous Winton Formation took up REEs from alkaline waters that appear similar to seawater, despite the fully terrestrial setting. New studies on REEs in lakes have yielded seawater-like REE patterns. Patterns inherited from groundwater residing in limestone aquifers and different patterns inherited from local soils, but the source of other seawater-like REE patterns is still to be determined.

Grant Information:
Funding sources: Australian Research Council grants (DP120101752, DE120101533, LE0989067), Ian Potter Foundation, Petrobras

Technical Session IX (Thursday, October 10, 2019, 4:00 PM)
THE GOOD, THE BAD AND THE UGLY – ALTERATION EFFECTS ON DENTAL MICROWEAR TEXTURES AND THEIR IMPLICATIONS FOR DIET RECONSTRUCTION

WEBER, Katrin, Johannes Gutenberg-University, Mainz, Germany; WINKLER, Daniela E., Johannes Gutenberg-University, Mainz, Germany; KAISER, Thomas, University Hamburg, Hamburg, Germany; SCHULZ-KORNAS, Ellen, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany; TÜKEN, Thomas, Universität Mainz, Mainz, Germany

Teeth are often the only parts of vertebrates preserved in the fossil record and thus represent a valuable source of information about the diet and feeding behaviour of extinct taxa. In vertebrates, dental microwear texture analysis (DMTA) has long been used to assess the material properties of food items as well as the presence of external abrasives attached to them. Abrasion by ingested food and attrition cause the loss of surface materials resulting in microscopic wear damages which enable us to infer dietary tendencies, and distinguish soft- from hard-object feeders among herbivorous and faunivorous ungulates, rodents, crocodiles, and sharks. Teeth were tumbled in sediment-water suspensions using four grain size fractions of fine sand to fine gravel. Preliminary results show visible changes in enamel surface features after tumbling, however, these surface modifications are not statistically significant. Additionally, a sand blasting experiment with mineral dust, to test for the effect of mechanical processes, showed that teeth in sediment-water suspensions have much lower landmark displacement magnitudes than the rest of the skull, both along the main ordination axis of shape variation and between the specimens that were most divergent in Procrustes space. Our results confirm the long-held expectation that shape variation in the basicranium is relatively low compared to the rest of the skull. However, in a 3D context, this does not translate into higher levels of phylogenetic information contained in the basicranium; rather, cranial function seems to be an important driver of marsupial basicranial topology, with strong potential for a confounding effect with phylogenetic signal.

Grant Information:
Funded by Australian Research Council DP170103227 and FT180100634 and National Science Foundation BCS 1552848/1825129 and DBI 1701714

Symposium: Quaternary Extinctions (Friday, October 11, 2019, 1:45 PM)
DATING THE RISE AND FALL OF ORANGUTAN (PONGO SP., HOMINIDAE) THROUGH THE QUATERNARY OF SOUTHEAST ASIA

WESTAWAY, Kira E., Macquarie University, Sydney, Australia; JOANNEY-BOYAU, Renaud, The University of Queensland, Brisbane, Australia; BACON, Anne-marie, UPR2147 (CNRS), Paris, France; LOUYX, Julien, Griffith University, West End, Australia; ZHAO, Jian-xin, University of Queensland, Brisbane, Australia

Orang-utans (Pongo sp.) are a key member of the dominant Stegodon-Ailuropoda fauna of Southeast Asia and their teeth have been discovered within most of the main cave sites within this region. This fauna is intimately connected to the evolution and dispersal of Homo throughout Southeast Asia and yet very little is known about the context of the assemblage, its age, environmental conditions and ecology. As Pongo is only able to survive in enclosed rainforest conditions their presence and absence play a critical role on reconstructions of the paleoenvironments of this region. These reconstructions can only be established within solid chronological framework that relies on multiple supporting dating techniques. We present Pongo chronologies from nine cave sites (Lida Ajer, Pumung, Kota Batu, Kota Badak, Tan Hung, Duoi Uoi, Nam Lot, Bob Dambung and Coe mug) within five different countries that were established using a combination of luminescence (pIR-IRSL, single grain and red thermoluminescence) dating of the surrounding sediments, electron spin resonance (ESR) dating of the teeth and Uranium-series dating of flowstone that cap the deposits. This timeline, ranging from 270±25 ka (from marine oxygen isotope stage 3) to 8.2±0.6 Ma (from oxygen isotope stage 8-2), charts the arrival, rise and potential of fall of the Pongo species in the region. This represents unparalleled evidence for the evolutionary trajectory of Pongo...
in Southeast Asia and has implications for the now extinct fauna of the Stegodon-Ailuropoda assemblage, especially the infamous giant ape (Gigantopithecus blacki), and for our understanding of Asian megafauna and the human story in the region.

Grant Information:
This research was funded by an Australian Research Council Discovery grant (DP1903049) to KW

Regular Poster Session IV (Saturday, October 12, 2019, 4:15 - 6:15 PM)
EVALUATING THE DIET OF HULHILITUS USING ORIENTATION PATCH COUNT (OPC)
WHITE, Joshua M., Dapto, Australia; MCCURRY, Matthew, Sydney, Australia; EVANS, Alistair R., Monash Univ, Monash University, Australia

In 1967, the fossil remains of an unusual diprotodontid were discovered in Papua New Guinea, named *Hulhilitus* [tomasettii](http://example.com). It was reconstructed adopting a panda-like posture based on its post-cranial morphology. It has also been suggested to occupy a similar niche to modern pandas, capable of consuming bamboo, however this claim has never been assessed. Here, we aim to infer the diet of *H. tomasettii* in contrast to other members of Diprotodontidae by measuring their dental complexity. Dental complexity is a homology-free method that measures the topographic features on the tooth’s surface, and previous studies have shown it to correlate with diet. This method is also capable of distinguishing bamboo feeders from generalist herbivores. We found that *H. tomasettii* does not exhibit the dental complexity observed in bamboo specialists and are similar to other diprotodontids. The results of this study provides more insight into the paleobiology and diversity of Diprotodontidae. Additionally, this will contribute to our understanding of how the diet of marsupials changed over time in response to environmental shifts.

Education and Outreach Poster Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)
FIELDWORK INSPIRING EXPANDED LEADERSHIP AND DIVERSITY (FIELD): OVERCOMING BARRIERS TO FIELDWORK IN PALEONTOLOGY
WHITE, Lisa D., University of California, Berkeley, Berkeley, CA, United States of America; PAGNAC, Darrin C., South Dakota School of Mines and Technology, Rapid City, SD, United States of America; BOWSER, Gillian, Colorado State University, Fort Collins, CO, United States of America

Field activity is integral to many subdisciplines of geology, paleontology, and associated field disciplines and the dominant, long-standing cultures within these disciplines continue to set the norms for fieldwork expectations. Individuals who are underrepresented in STEM (e.g., people with disabilities, ethnic minorities, women, LGBTQ individuals) particularly face barriers with field activity. These can include feelings of economic exclusion, anxiety about outdoor experiences, attitudes of ableism, and accessibility. These barriers are often ingrained in the culture of field training and research activities, which continues to emphasize physical ability, mental toughness, assertive behavior, and one-upmanship. This project aims to make field activity in the geosciences more accessible, culturally sensitive, and inclusive by equipping field leaders with the perspectives, skills, and solidarity to address both physical and cultural barriers in field settings. Led by a team of PhDs and senior personnel from nine institutions representing paleontology, geology, field ecology, marine science, atmospheric science, and social science, the goal of FIELD is to understand the nature of field culture, understand the ways field activity can be exclusionary, and to explore potential solutions. Here we present some of the results from a 4-day immersive leadership development institute at the Colorado State University Mountain Campus for field course leaders in October 2018. Our goals were to: (1) engage in practical skills training such as bystander intervention and diversity leadership; (2) collaboratively develop new approaches to reduce the exclusionary nature of field culture; (3) explore multidisciplinary and mixed methods that can inspire a love of field activity in a wider range of participants. The venue provided a space for often-difficult conversations about the culture of field sciences that are, in large part, a function of its leaders unquestioning socialization into it but that frequently excludes others. These activities and conversations form the basis for a model of professional development and leadership training that can be disseminated, scaled, and used by others who design field projects in paleontology and similar field-based disciplines. It is our hope that through these FIELD activities, participants and leaders will be inspired and motivated to create more inclusive field activities.

Grant Information:
The FIELD project is supported by NSF awards #1645449 and #1645466

Technical Session VII (Thursday, October 10, 2019, 8:45 AM)
AN UNUSUAL FOSSIL LOCALITY FROM THE LATE CRETACEOUS HORSESHOE CANYON FORMATION OF SOUTHERN ALBERTA, CANADA REVEALS RARE ELEMENTS OF A PALEOCOMMUNITY.
WHITEBONE, S. Amber, University of Calgary, Calgary, AB, Canada; FUNSTON, Gregory F., University of Alberta, Edmonton, AB, Canada; CURRIE, Philip J., University of Alberta, Edmonton, AB, Canada

The Late Cretaceous rock deposits of southern Alberta, Canada yield an abundance of vertebrate fossils. However, preservation biases in terrestrial depositional systems result in certain aspects of the flora and fauna from these formations being disproportionately rare. For example, the fragile skeletons of small theropod dinosaurs are generally uncommon, as are the smaller juvenile ontomorphs of most taxa. Within the Late Cretaceous Horseshoe Canyon Formation, such taxa are more frequently found in microsite assemblages (concentrations of small (<5 cm) fossils) that preserve elements from small, rare taxa alongside teeth and small bones of larger taxa. These microfossil assemblages are therefore critical for paleocommunity reconstruction. Here we describe a new microfossil bearing locality from the Horsethief member of the Horseshoe Canyon Formation. Of interest is the unusual abundance of troodontid and anuran material, as well as the presence of perinate material from various taxa. In addition, this site is not restricted to microfossils, as several larger bones (ranging from 5 – 30cm) are found in the same horizon. The depositional environment is that of an overbank deposit with little to no marine influence and likely represents a slow accumulation of sediment and the absence of secondary reworking. By extension, we suggest this faunal assemblage is a closer representation of the true biological association than assemblages from secondarily reworked microsites, allowing for novel paleoecological interpretations.
Dicynodonts were a diverse and distinctive clade of non-mammalian synapsids that originated in the middle Permian and persisted until at least Late Triassic times. One of the most distinctive features of the group are the paired maxillary tusks found in most genera. Descriptions of tusk tissue composition and development report variation yet oftentimes dicynodont tusks are viewed as stereotyped and uninformative within the group. Despite tusks being the namesake of the clade, no systematic histological analysis of tusk development and tissues in a phylogenetic context has been conducted. Here we present findings from work that more precisely characterizes the tissues and development of tusks in a sample of genera that spans dicynodont phylogeny (e.g., Dictodon, Oudenodon, Aulacephalodon, Lystrosaurus). Our findings reveal unsuspected variation in tusk tissues, composition, and attachment, as well as developmental strategies. We found a consistent correlation between development and tooth attachment, with permanent gomphosis in ever-growing tusks and an ankylosis in closed-root tusks. However, the tissues of the tusk were varied and less consistent with development and mode of attachment. Of particular note is our recognition of an enamel capping tissue in some Dicynodontoidea indet. tusks from the upper Madumabisa Mudstone Formation of Zambia. Preliminary data suggest that these tusks were ever-growing, yet unlike ever-growing teeth in extant mammals like rodents, enamel surrounds the entirety of the tusk. Together these data provide additional characters for dicynodont systematics, insight into the correlative evolution of dental characters, and reveal possible novel developmental patterns in the ever-growing teeth of extant tuatara.

Grant Information:
National Geographic Society 158R-18

Symposium: From Molecules to Macroevolution (Wednesday, October 9, 2019, 8:15 AM)
of acetic acid, and then washing thoroughly with water. This process was repeated many times until the desired level of preparation was achieved. During preparation, however, bone deterioration and loss of detail threatened to become a problem. Kunharrasaurus has a layer of small dermal ossicles, about 3 - 5mm in diameter, that we aimed to keep intact wherever possible. Areas containing these small elements were coated with extra layers of Paraloid B72, however after continual exposure to acid small ‘pinprick’ holes appeared, even when additional coats were applied between acid treatments. This resulted in undesired dissolution of the matrix and loss of some of the ossicles. It was best practice to keep high-risk areas out of acid altogether by propping the specimen but often these areas had to be submerged to allow the acid level to reach unprepared matrix. Mechanical preparation was too risky because the ossicles were too small and embedded randomly in matrix where micro-fracturing would threaten them. In 1994, a new technique was adopted which involved targeted application by dripping acid from an intravenous drip kit mounted above the specimen. The advantages included small amounts of acetate crystals appearing on the edge of the acid flow and slower preparation time. After using the technique in conjunction with standard immersion methods for a period of 12 months, the results showed that we could prepare quite selectively along the edge of fossil bone without affecting the rest of the block. Over the past 20 years, this technique has been used for other specimens with similarly beneficial results.

Technical Session II (Wednesday, October 9, 2019, 8:15 AM)
WHAT IS AND CAN BE KNOWN ABOUT THE WINTON FORMATION? UNDERSTANDING THE GEOLOGY OF THE WINTON FORMATION AND INTEGRATING NEWLY DISCOVERED FOSSIL FIELDS FROM SOUTH-WEST QUEENSLAND, AUSTRALIA

WILKINSON, Melville, Santos, Brisbane, Australia; HOCKNULL, Scott A., Queensland Museum, Brisbane, Australia; MACKENZIE, Robyn, Eromanga Natural History Museum, Eromanga, Queensland

The Winton Formation (WF) is the largest terrestrial depositional system from the Cretaceous part of the Eromanga Basin, occurring across QLD, NSW, SA, and the NT. Our study evaluates what conclusions can be drawn from the available geological and palaeontological data, much of which is based on limited local core and localised outcrop data with fossil sites concentrated in the northern part of the basin. We have incorporated extensive regional subsurface data and local observations from newly discovered fossil sites from the central-eastern portion of the basin near Eromanga and Quolpie. Considerable complexity in preservation and depositional history of the WF is observed at regional and local levels resulting in poor resolution of stratigraphic and temporal relationships. Significant post depositional structural and depositional events have caused extensive modification, resulting in the loss of the proximal and distal margins of the WF, burial of up to 1100 metres of section and extensive differential weathering. The WF consists of a spatially and temporally complex mosaic of depositional environments ranging from marginal marine and coastal plain to large scale “anastomosing” fluvial systems consisting of widely spaced “trunk” rivers separated by large relatively flat floodplains subject to frequent avulsion. We present for the first time a regional isopach map, with all known fossil sites, occurring in the basin 250-400 metres. Fossil sites to the NE of Winton are lowest in the section, being closest to the preserved basin margin. The map is constrained to a resolution of 100 metres at best, due to limited and uncertain data, with trends reflecting structural events. Therefore, use of such an isopach to make fine scale stratigraphic comparisons between fossil sites must be cautioned. For example, equivalent isopachs do not imply coeval time due to differential subsidence and the diachronous nature of the WF. Depositional environments observed at fossil sites are interpreted to be associated with large floodplains, with those in Eromanga more distinct and labile relative to those from NW Winton, while sites NE of Winton may be closer to the coastal plain. To date, no fossil sites have been found within large fluvial channels. On the basis of the variable local depositional environments, complexity of preservation, and isopach uncertainty across the WF, any finer scale stratigraphic comparisons are precluded. Therefore proposed macro-scale stratigraphic comparisons are unsupported or equivocal, even when detrital zircon data is considered.
Betonnie-Tsosie Wash are as much as 0.3 Ma younger. Together, they reveal that Na-zin Wash area are older and near the base of C29n. Those of Kimbeto and Paleocene.

from the lower Tn and underlying Ojo Alamo Sandstone. Together, these recently, a diverse early Paleocene megaflora has been collected, particularly Puercan) and Tj1 – Tj6 (spanning chron C28n – C27n; Torrenjonian). More that “large” herbivorous peryptichid “condylarths” (e.g., Ectenosaurus [<100 kg] and Carusotyphus [~25 kg] were present within 0.4 Ma of the K-Pg boundary. Moreover, the diverse Pu2 faunas of Kimbeto and Betonnie-Tsosie washes are a mere 100 ka older than the late Puercan (Pu5) faunas of De-na-zin Wash and consequently, indicate extremely high levels of mammalian turnover between these faunas. A long gap, the “barren interval”, spanning about 1.18 Ma separates Puercan and basal Torrenjonian faunas, which first appear near the base of C28n, hampering investigation of the turnover in mammals across the Puercan/Torrejonian boundary. However, the megafossil record is much more complete across this interval, and documents a major restructuring of plant communities across the Pu2-P3 and Pu3-Tol1 transitions, very low rates of origination throughout Pu3, and a large extinction at the Pu5-Tol1 boundary. Taken together these data indicate that the Puercan and Torrenjonian terrestrial biota in the SJB were characterized by significant and rapid biotic turnover.

Grant Information:
National Science Foundation (DJP, RS, SLB, SLS, TFW), U.S. Bureau of Land Management (SLB, TEW), SEPM (CL), and American Chemical Society Petroleum Research Fund (DJP)

Technical Session I (Wednesday, October 9, 2019, 8:30 AM)
INFERENCES ON PLEISAOAURIAN METABOLIC RATE AND VASCULAR SYSTEM FROM NUTRIENT FORAMINA IN LONG BONES
WINTRICH, Tanja, Geoscience, Bonn, Germany; FLEISCHLE, Corinna, Geoscience, Bonn, Germany; SANDER, P. Martin, Geoscience, Bonn, Germany

Plesiosaurs were secondarily aquatic reptiles showing a unique and uniform bouplan highly adapted to the marine environment. Plesiosaurs are a long-lived and diverse clade, with records all over the globe dating from the latest Triassic to the terminal Cretaceous. Quantitative and qualitative analysis of long bone histology suggests that plesiosaurs were endothermic marine reptiles with fast growth and elevated metabolic rates in the range of birds. Beside histological evidence, blood flow through the nutrient blood vessels of long bones connecting the medullary region with the non-skeletal vascular system may provide evidence for a high metabolic rate. Blood flow is correlated with the diameter of the nutrient foramen, and measurements in fossil thus can be used to infer blood flow based on data from recent tetrapods. Plesiosaurs have distinctive and large nutrient foramina in their propodials (humerus and femur look very similar and sometimes indistinguishable), providing a proxy for blood flow easily accessible to measuring on the bone surface and in CT scans. However, the vascular system in fully aquatic tetrapods is different from that of terrestrial tetrapods, especially in deep divers. Extant terrestrial amniotes may thus be unsuitable for comparison with plesiosaurs, leading us to collect comparative data for extant marine amniotes. We hypothesized that, as in terrestrial amniotes, relative foramen size depends on activity metabolic rate (low in sea turtles vs. high in cetaceans, pinnipeds, and penguins) in addition to body mass. We collected data for nutrient foramen diameter from numerous femora and humeri of plesiosaurs of Triassic to Cretaceous age, but also from Triassic basal sauropotygyxians such as nothosaurs and plesiosaurids. The relative diameter of the plesiosaur propodial nutrient foramen is in the range of endothermic marine amniotes, consistent with the histological evidence, whereas basal sauropotygyxians have smaller foramina.

Nutrient foramen diameter and thus blood flow in plesiosaurs may have been influenced by other parameters as well. Thus, it is unclear if plesiosaurs could have lowered blood pressure during deep diving by constraining the main vessels, as seen in modern whales, and how this would have affected foramen diameter. Furthermore the special vascular system linked to notopty in the cervical vertebrae of plesiosaurs may have influenced blood flow as well. Symposium: Quaternary Extinctions (Friday, October 11, 2019, 2:30 PM)
REASSERTING THE SIGNIFICANCE OF THE QUATERNARY MACROFAUNAL NECROPOLIS FROM LAKE CALLABONNA, SOUTH AUSTRALIA
WORTHY, Trevor H., Flinders University, Adelaide, Australia; ARNOLD, Lee H., University of Adelaide, Australia; CHINSAMY, Avexiam, University of Cape Town, Rhodes Gift, South Africa

Lake Callabonna, a large, episodically dry salt lake in north-eastern South Australia’s desert region, became famous for Quaternary macrofaunal remains following the discovery of Diprotodon and giant bird bones there in 1892. Nine months of excavations for the South Australian Museum in 1893 revealed many fossils described by FC Stirling and AHC Zietz in a succession of papers over the following decade. Notable among these were a series of papers describing Australia’s largest marsupial (Diprotodon optatum) and its then largest bird Genyornis newtonii (Dromornithidae). The site then lapsed into obscurity and was not revisited again until 1973 in an expedition led by Dick Tedford, leading to recovery of important new macropod remains. There have been few expeditions to explore the fossil bone resources since then, yet important questions remained. Notably, what was the age span of these fossil deposits? What are the relative abundance of taxa? In expeditions in 2013, 2014 and 2018, we sought data to address these issues to help clarify the paleoecology of Late Quaternary macrofauna. Specifically, we mapped about 450 surface exposures of individual skeletons. Stratigraphic observations combined with an extensive Optical Dating programme show that the site spread over about 12 km of the lake suggest that all fossils derive from a narrow time interval reflecting a drought period of several millennia between 50 and 40 kyrs. This period overlaps with presence of humans in Australia and the Flinders Ranges only some 50-80 km distant. Twelve megafloral taxa are now known from the site including Diprotodon, Phascolonus, 7 kangaroos (3 sthenurines, 2 Protemnodon sp, 1 Baringa,1 Macropus), two birds – Genyornis and Dromaius – and the giant varanid Varanus priscus. The extent taxa are thus firmly placed in temporal overlap with humans, thereby showing that humans cannot be discounted from having a causal role in their extinction. Important discoveries include pouch young in thus firstly sexed articulated Diprotodon and Protemnodon skeletons, well preserved gut contents in Diprotodon, feather and skin impressions, and the first well preserved skull material of Genyornis. The latter shows Genyornis had a highly derived skull similar to those of other dromormithids, but with a much shorter, although still very deep and narrow bill, and thus had affinity to Ibdooroors. Collectively, a thorough examination of Lake Callabonna helps clarify the timing of megafloral extinction in Central Australia and provides significant insights into the biology of several taxa.

Grant Information:
ARC Discovery Project DP180101913

Symposium: Origin of a Sunburnt Country (Saturday, October 12, 2019, 8:45 AM)
CRUSHING IT: THE SPECIALISED CRANIAL MECHANICS OF AN EXTINCT SHORT-FACED KANGAROO
WROE, Stephen, University of New England, Armidale, Australia; MITCHELL, Rex, Armidale, Australia

The sthenurines were a subfamily of robust kangaroos that arose in the Miocene and diversified in the Pliocene/Pleistocene. This now extinct clade included the largest species of kangaroo to ever exist (max ~250kg, Procoptodon goliah), substantially larger than the largest extant species, the red kangaroo (max ~90kg, Macropus rufus). Yet, little of their ecology has been quantified. More accurately predicting diets within this once diverse and widely distributed group of iconic Australian megafauna will improve our understanding of not only their ecology, but also of past environments. Cranial morphology correlates with foraging behaviours and mechanical properties of plant tissues among extant kangaroos and relatives (Macroptilidium). Here, we first used shape analysis (Geometric Morphometrics) and biomechanical simulations (Finite Element Analysis) to examine cranial shape and compare the mechanics of biting at the incisors across several extant diprotodont herbivores. Based on these findings we predict the diet of a well-represented species of sthenurine, Simosthenurus occidentalis. We found that a combination of craniofacial proportions and a large size and robust morphology could potentially incorporate particularly thick, resistant vegetation into its diet. Further biomechanical analyses were conducted focusing on unilateral biting along the cheek teeth. Using simulations demonstrate that it greatly hypertrophied zygomatic arch likely

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housed an enlarged zygotomicondibularis muscle, which reduced the risk of tooth dislocation during rear molar bites of extraordinarily high mechanical efficiency. Furthermore, we show that the flared frontal plates of these species align with the axes of torsional forces, reinforcing the cranium against axial twisting during hard unilateral bites on resistant foods. This supports previous suggestions that the toughest vegetation was likely fed directly to the premaxillae and crushed; possibly in a similar manner to the way a panda crushes mature bamboo culms. These findings provide evidence of a herbivorous niche, incorporating particularly tough plant matter, not represented among marsupial herbivores today. Such a niche may have been realized in response to the unpredictable availability of quality forage during Pliocene/Pleistocene glacial cycles.

Technical Session X (Friday, October 11, 2019, 11:15 AM)

PROGRESS IN THE RESEARCH ON THE CENOZOIC FISH FAUNA FROM THE TIBETAN PLATEAU

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Research on life history of the Tibetan Plateau (TP) has intensified for the past ten years. The fossil fish materials we have collected are abundant and widely distributed on TP. These newly found fossils reveal the major shift of the fish fauna during the Cenozoic and highlight the role of the rising TP played in the formation of the intercontinental distribution of some freshwater fishes. Our studies show that the modernization in the fish fauna on TP may have occurred no earlier than the Pliocene. The fossils of primitive snow carps were discovered from the lower Miocene of the central TP and the Pliocene of Qaidam basin, when these areas were relatively low, and the highly specialized snow carps were known from the upper Pliocene of Kunlun Pass in the NE Tibetan Plateau and the Pliocene of Zhada basin in SW Tibetan Plateau, now the territories of the highly specialized snow carps. The diversification of jaw dislocation during rear molar bites of extraordinarily high mechanical efficiency. Furthermore, we show that the flared frontal plates of this species housed an enlarged zygomaticomandibularis muscle, which reduced the risk of dental replacement teeth and their tooth families. 3D reconstruction of the replacement tooth rows shows a conserved alternating pattern as seen in other archosaurs. In addition, we apply a new morphologic framework (quantitative and qualitative) for organizing tooth diversity in enantiornithines. Using parameters such as crown base length, crown height, apical length, curvature, enamel ornamentation, number of teeth on each tooth-bearing bone, and dental spacing, the dental anatomy of the two new species closely resembles the pattern described for the stem group, whereas the dental morphology and enantiornithines provide a morphologic framework that can be applied to other toothed avian clades in order to understand dental evolution in stem birds.

Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)

EVALUATION HOMOLOGY IN THE FIN-TO-LIMB TRANSITION: EVALUATING THE MORPHOLOGY OF FORAMINA IN A LATE DEVONIAN HUMERUS FROM THE CATSKILL FORMATION, CLINTON COUNTY, PENNSYLVANIA

WYN, Brenen M., Virginia Tech, Blacksburg, VA, United States of America; DAESCHLER, Ted, The Academy of Natural Sciences, Philadelphia, PA, United States of America; STOCKER, Michelle RY, Virginia Polytechnic Institute and State University, Blacksburg, VA, United States of America

The evolution of early tetrapods is marked by several morphological shifts, including the evolution of a neck and weight-bearing limbs. The humerus plays a central role in the reorientation of the appendage from a posteriorly-directed fin to a laterally-directed limb used in terrestrial locomotion. Through the reorientation of the forelimb, a humeral process called the ventral ridge transitions from a diagonal to parallel orientation relative to the humeral head. Throughout this transition, the ventral ridge is pierced by proximodistally trending foramina, as well as a dorsoventrally trending foramen that has been homologized with the entepicondylar foramen, which houses the brachial artery and median nerve in living taxa. These ventral ridge foramina have been briefly interpreted as vascular channels, however the structures that pass through these foramina, their homology, and their evolutionary origin have yet to be critically evaluated in the context of the fin-to-limb transition. We used micro-computed tomography to reconstruct the humeral foramina morphology in a stem tetrapod (ANSP 21350) from the Late Devonian of Pennsylvania. We hypothesize that these foramina are an osteological result of the ventral ridge osteology surrounding neurovasculature. The ventral ridge of stem tetrapods house a single, large foramen that has been homologized with the entepicondylar foramen and suggest that the large foramen in ANSP 21350 housed both a nerve and vasculature. The retention of neurovasculature within the ridge through the reorientation of the humerus suggests that neurovasculature that supplied signals to the distal limb were conserved within the ventral ridge, whereas accessory vasculature moved outside of the ridge. Furthermore, we infer that the functional evolution of the forelimb in the fin-to-limb transition drove shifts in the location of forelimb neurovasculature.

Regular Poster Session I (Wednesday, October 9, 2019, 4:15 - 6:15 PM)

A REVIEW OF MESOZOIC FOSSIL FEATHER MORPHOLOGIES: PROBLEMS AND PROSPECTS

XU, Xing, Institute of Vertebrate Paleontology & Paleoanthropology, Beijing, China

Recent discoveries of feathers and feather-like integumentary structures in various archosaurian fossils, particularly those present in theropod fossils, have significantly advanced our understanding of the origin and early evolution of feathers. At the macroscopic level, the major feather morphotypes, including flight feathers with asymmetrical vanes, have been...
identified among non-avialan archosaurs. However, the occurrence of certain major feather structural components (e.g., calami, after feathers, and barbules) and their morphological details, are not well known in most previously reported Mesozoic fossil feathers or feather-like integuments. At the microscopic level, many theropod and other vertebrate fossils have demonstrable preservation of melanosome pigment structures including some highly specialized ones with a limited taxonomic distribution among extant birds, and some are hypothesized to preserve keratin proteins, but the identifications of both the structures and chemical composition of the fossils have been questioned.

Here, I review the major discoveries of Mesozoic fossil feathers and feather-like integuments, comment on the preserved morphologies at both the macro- and microscopic levels in these fossils, and discuss the distribution of these morphologies across space, time, and phylogeny. I highlight some issues that remain under debate or are otherwise unresolved, including: at what point in archosaurian phylogeny the first feathers originated; how some major structural components of feathers evolved; whether early feathers developed ontogenetically in the same way as modern feathers; whether they share similar biochemical components with modern feathers; whether the major features of feathers appeared incrementally during their evolution (or with some having appeared simultaneously); whether feather-related features have evolved in concert at the macro- and microscopic levels; and lastly examining what were the primary functions of various early feathers. In addition, I highlight several problems pertaining to the study of the origin and early evolution of feathers such as how to define what a feather is and how to optimize feather-related features on the phylogeny while considering the difficulty of differentiating the absence of evidence, from evidence of absence, in the study of fossil soft tissues, and finally, I provide tentative suggestions for future research directions.

Grant Information:
National Natural Science Foundation of China (Grant No. 41688103) and the Strategic Priority Research Program of the Chinese Academy of Sciences (Grant No. XDB18030504)

Symposium: Origin of a Sunburnt Country (Saturday, October 12, 2019, 9:15 AM)
THE LAST 10 MILLION YEARS OF AUSTRALIAN CROCODYLIAN HISTORY: A CASE OF OUT WITH THE OLD AND IN WITH THE NEW

YATES, Adam M., Museum and Art Gallery of the Northern Territory, Alice Springs, Australia

The history of crocodylians in Australia over the last 10 Ma is one of turnover, with an old endemic clade called Mecosuchinae being replaced by the genus Crocodylus which dispersed into Australia from Asia. However, the turnover was not simple and involved three independent invasions of Australia by Crocodylus. Mostly the arrivals of Crocodylus do not appear to be correlated with any of the extinction events that affected both mekosuchines and Crocodylus over this period.

The first extinctions seem to have hit near the end of the Miocene and resulted in the loss of the large Baru, and an unnamed dwarf mekosuchine. These extinctions may be part of a worldwide drop in crocodylian diversity related to global cooling. Other mekosuchines survived, including Quinckhana, Kalthiforns and an unnamed taxon traditionally placed in ‘Pallimnarchus’. The oldest crocodyllus fossil from Australia is from the mid Pliocene of Queensland and has been referred to the extant C. porosus. However, there are no autapomorphies or unique combination of characters to support this and at least one feature suggests that it is not C. porosus. Indeed, none of the other Australian fossils referred to C. porosus withstand scrutiny, leaving C. porosus without an Australian fossil record.

Crocodylus dispersed to the Lake Eyre Basin of South Australia by the late Pliocene. The South Australian Crocodylus appear related to, but specifically distinct from, the Pliocene Crocodylus of Queensland. The new species replaced Kalthiforns, whereas in Queensland ‘Pallimnarchus’ continued to live alongside Crocodylus. The South Australian fossils are complete enough to allow the diagnosis of a new species. Phylogenetic analysis indicates that the new species is more closely related to C. palaeindicus from the Pliocene of Asia than it is to the extant Australian species. By the end of the Pliocene Crocodylus was extinct in Queensland while ‘Pallimnarchus’ continued to survive, as did C. sp. nov. in the Lake Eyre Basin. At some point prior to the late Pliocene a new lineage of Crocodylus entered Australia and evolved into the endemic C. johnstoni. Extreme aridity in the Late Pleistocene wiped out Crocodylus n. sp. in the Lake Eyre Basin, while a later pulse of extinction, probably associated with the loss of Quinckhana at around 42 Kya, saw the loss of Quinckhana and ‘Pallimnarchus’ from more mesic habitats. C. johnstoni survived this extinction and was joined by C. porosus. The timing of the arrival of C. porosus is unknown but it could postdate the late Pleistocene megaflaunal extinctions.

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Hadyrados and ceratopsians are two major groups of ornithischian dinosaurs. During their evolutionary history, they acquired many similar changes including increase of body size, bipedal-quadrupedal transition, and dental battery structures. However, the developmental trajectories of these evolutionary changes are barely known mainly due to paucity of fossils in early developmental stages and technical limitations.

CT scan has been widely used in many fields for 3D imaging, however, whose subsequent classification, labelling, and segmentation, are often laborious and prone to error. Since 2013, Deep Neural Networks (DNNs) have reached significant success in computer vision tasks. As CT scan and other 3D imaging techniques are more frequently applied in paleontological research, traditional data processing methods cannot fulfill the requests from either enhanced sample size or higher image resolution. The application of deep learning for automated segmentation and labelling can avoid the possibility of damaging precious fossils during preparation or observation, and save considerable time for paleontologists from 3D data processing.
Colbert Prize Poster Session (Wednesday - Saturday, October 9-12, 2019, 4:15 - 6:15 PM)

JAW MUSCULATURE IN PAREIASAURS AND PROCOLOPHONIDS

ZAHNER, Marta, University of Bristol, Bristol, United Kingdom; SENNIKOV, Andrey G., Russian Academy of Sciences, Moscow, Russia; BENTON, Michael J., University of Bristol, Bristol, United Kingdom; RAYFIELD, Emily J., University of Bristol, Bristol, United Kingdom

Pareiasaurs were a group of amniotes that included pareiasaurs - one of the largest representatives of the first herbivorous tetrapods in the Permian, and procolophonids - important representatives of post-mass-extinction recovery faunas in the Triassic, among other less taxonomically diverse clades. Albeit crucial for the Permian and Triassic ecosystems (that were precursors to the dinosaur faunas of the Late Triassic), pareiasaurs and procolophonids have been historically underrepresented in studies that did not focus on anatomical descriptions or amniote phylogeny. Here we present the first stage of a comparative biomechanical study of selected pareiasaurs, a detailed reconstruction of the adductor musculature of three procolophonid taxa (Tichinskia, Kapes, and Pentaedrusaurus) and three pareiasaur taxa (Delavaria, Scutosaurus, and Elginia) based on three-dimensional models. Such models allow for more accurate measurements of muscle attachment sites, from which muscle and bite force estimates were calculated using the anatomical cross-sectional area of the reconstructed muscles (as ratio of muscle volume and muscle length) and the isotropic stress value of 0.3 N/mm^2. For calculating mechanical advantage, the lower jaws were observed as a third-class lever system with the inlever being distance from the jaw joint to adductor muscle attachment, and the outlever being distance from the jaw joint to the anterior-most and posterior-most dentary teeth. We find there is little variety in bite force and mechanical advantage within each group, but procolophonids as a group show higher bite forces and more relative adductor muscle mass than pareiasaurs. Relatively low bite forces in pareiasaurs were suitable for collecting, but not so much for further oral processing of soft plants. Stronger bite force in procolophonids was achieved by posterior elongation of the skulls and enlarging adductor muscle attachment sites on the mandible. With a lower mechanical advantage, Tichinskia was possibly adapted to fast piercing of arthropods, and later taxa for crushing fauna and flora. Higher mechanical advantage possibly allowed limited oral processing in procolophonids, relevant as the group lacked the enlarged gut of pareiasaurs. These muscle reconstructions and digital models will be used in the future studies to perform stress-strain analyses on the skulls and mandibles, using Finite Element Analysis.

Grant Information:
This study has been funded by the Faculty of Science, University of Bristol.
Grant code: GELY H/8922 (3630)

Technical Session XVII (Saturday, October 12, 2019, 9:30 AM)

EVALUATORY RATES IN TYNANOSAURIDAE SUPPORT A MODEL OF ECOCLOGICAL RELEASE LINKED TO THE EXTIRPATION OF CARCARCHODONTSAURS

ZANNO, Lindsay, North Carolina Museum of Natural Sciences, Raleigh, NC, United States of America; GATES, Terry A., NC State University, Raleigh, NC, United States of America

Intensified sampling of mid-Cretaceous paleobiotas across Laurasia is providing new data on predator dynamics, specifically the opportunistic Intensified sampling of mid-Cretaceous paleobiotas across Laurasia is providing new data on predator dynamics, specifically the opportunistic Intensified sampling of mid-Cretaceous paleobiotas across Laurasia is providing new data on predator dynamics, specifically the opportunistic Intensified sampling of mid-Cretaceous paleobiotas across Laurasia is providing new data on predator dynamics, specifically the opportunistic Intensified sampling of mid-Cretaceous paleobiotas across Laurasia is providing new data on predator dynamics, specifically the opportunistic Intensified sampling of mid-Cretaceous paleobiotas across Laurasia is providing new data on predator dynamics, specifically the opportunistic

The Early Cretaceous Lioinngosaurus paradoxus from western Liaoning is among the best-represented ankylosaurians in terms of the quantity and quality of the recovered specimens, but it has never been fully described since the brief report naming the taxon. Here we provide new morphological information derived from close examination of the holotype and three new specimens of Lioinngosaurus paradoxus. The revised diagnosis of Lioinngosaurus paradoxus includes the elongated adanal rib extending posteriorly to the posterior end of the third cervical centrum, the axial neural spine sub-rectangular in lateral view, the anterior caudal centra subequal in phylogenetic matrix rate tests, and ridge regressions). Our data indicate that a phylogenetic view of body size in ankylosaurs across the 90 million years of evolution is best explained by random (Brownian) evolution; however, we document a significant trend of increasing rates and phenotypic means in BM evolution after the hypothesized extirpation of carcarchodontosaurs in the Turonian (mean sustained increase in FL of 1.35 cm [range 1.15 to 1.70 cm] per 1 m) per they, supporting a hypothesis of ecological release with directional selection (98.8% of sampled MPTs). This backdrop of increasing rates of BM, coincides with high rates of skeletal evolution (tested via morphological character datasets), which spoke above background levels near the root of Eutyrannosaurus, as predicted, and stabilize within the clade (Daspletosaurus + (Tyrannosaurus + Tarbosaurus)). Our results are consistent with a hypothesis of ecological release as a driver of ankylosaur evolution during the Late Cretaceous.

Technical Session VII (Thursday, October 10, 2019, 12:00 PM)

TOWARDS AN ADVANCED WEIGHTING APPROACH TO ACCOUNT FOR CHARACTER INTERDEPENDENCIES IN AN ADJUSTED PARSIMONY METHOD FOR PHYLOGENETIC INFERENCE USING PHYTOPHOTON DATA

ZHANG, Yue, Seattle, WA, United States of America; MORITA, Wataru, University of Helsinki, Helsinki, Finland; JERNVALL, Jukka, University of Helsinki, Helsinki, Finland

 Parsimony-based methods remain a powerful tool for estimating phylogenies from morphological data. In the minimum step method, the 100 million years of evolution across all the characters. Meanwhile, the extra step changing range often differs substantially among characters, or even among different coding schemes of the same character. When conflicts are present among the different phylogenetic contents contributed by individual characters, a consequence of this practice is that characters with a higher range of potential extra steps will have more influence on the analyses than characters with a lower range of potential extra steps. Whereas a large number of characters, of which the phylogenetic expressions are withheld for this reason, may still provide a meaningful reconstruction of the phylogeny, it is still worthwhile to explore alternatives for the minimum step method. Here we test an adjusted parsimony (AP) approach in which the scaling issue of character steps is taken into account. In addition, because the logical basis of scaling is built on one of the prerequisites for parsimony analysis, that is, each character is assumed to be independent from each other. It is, thus, necessary to consider character weighting, not commonly taken into account in the minimum step method. Character interdependencies arising from, for example, developmental bias need to be justified by weighting characters a priori. Character weighting a priori, however, does not have to be performed in the character analysis stage. Rather, weighting can be linked to the numerical analysis of character matrix. In the AP method, the phylogenetic content expressions of each character (E{i}) is calculated. When m characters interact and compete against each other for their phylogenetic contents (or can be any subset of the whole given data matrix), how E{i} for i = 1, 2, 3, ..., m change among all other potentially reveals how characters are interdependent. Another advantage of this approach is that character interdependencies found by AP are informative for the investigations aiming to uncover developmental or genetic links between different characters. A pilot set of data on murine dental characters analyzed using AP shows that the method can identify character interdependencies that are known to exist based on developmental biology studies. In future studies, it is expected that a well-structured weighting approach can provide a more refined way of using morphological data in phylogeny reconstructions.

Technical Session XII (Friday, October 11, 2019, 11:45 AM)

OSTEOLOGY OF LIOINNGOSAURUS PARADOXUS (ORNITHISCHIA: ANKYLOSARRA) FROM THE LOWER CRETACEOUS OF LIANING, CHINA AND THE EARLY EVOLUTION OF ANKYLOSAURIDAE

ZHENG, Wenjie, Zhejiang Museum of Natural History, Hangzhou, China; ZHENG, Xing, Institute of Vertebrate Paleontology & Paleanthropology, Beijing, China

The Early Cretaceous Lioinngosaurus paradoxus from western Liaoning is among the best-represented ankylosaurians in terms of the quality and quantity of the recovered specimens, but it has never been fully described since the brief reference to the species in the new taxa. Here we provide new morphological information derived from close examination of the holotype and three new specimens of Lioinngosaurus paradoxus. The revised diagnosis of Lioinngosaurus paradoxus includes the elongated adanal rib extending posteriorly to the posterior end of the third cervical centrum, the axial neural spine sub-rectangular in lateral view, the anterior caudal centra subequal in

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their anteroposterior length to mediolateral width, the manual phalangeal formula of 2:3:3:3:2, the femur about the same length as the tibia, shell-like ventral armor present, and pes approximately twice as long as manus. Additional significant features of Liaoningosaurus paradoxus include the plesiomorphic presence of premaxillary teeth and of the antorbital fenestra and the apomorphic presence of the elongated prezygapophyses and postzygapophyses of the posterior caudals interlocking the vertebrae to form a rigid tail club handle. Our phylogenetic analysis on a dataset comprising 59 taxa and 191 characters places Liaoningosaurus paradoxus as the most basal ankylosaurid. We discuss the evolution of major ankylosaurid characteristics of the skull and tail within the new phylogenetic framework, and suggest that mosaic evolution characterizes the early ankylosaurids, and in particular, the tail became specialized phylogenetically earlier than the skull in ankylosaurid evolution.

Grant Information:
National Natural Science Foundation of China (No. 41602019), State Key Laboratory of Paleobiology and Stratigraphy, China (No. 163120) and the Jurassic Foundation.

Technical Session X (Friday, October 11, 2019, 8:00 AM)

EARLY OSTEICHYAN EVOLUTION: INSIGHTS FROM NEW DATA OF THE SILURIAN MEGAMASTAX

ZHU, Min, Institute of Vertebrate Paleontology and Paleanthropology, Chinese Academy of Sciences, Beijing, China; AHLBERG, Per E., Uppsala University, Uppsala, Sweden; LU, Jing, Institute of Vertebrate Paleontology and Paleanthropology, Chinese Academy of Sciences, Beijing, China; CHOO, Brian, Flinders University, Adelaide, Australia; CUI, Xin dong, Institute of Vertebrate Paleontology and Paleanthropology, Chinese Academy of Sciences, Beijing, China; ZHU, You'an, Institute of Vertebrate Paleontology and Paleanthropology, Chinese Academy of Sciences, Beijing, China

Megamastax amblyodus from the Kuantu Formation (Late Ludlow, about 423 million years ago) of Yunnan, China, is by far the largest pre-Devonian vertebrate yet discovered, with an estimated length of about one meter. It was identified as a sarcopterygian because its external dermal bones are covered in cosmine with numerous embedded pores. However, reconstructing its phylogenetic position has been impeded by the limited data (two isolated postzygapophyses of the posterior caudals interlocking the vertebrae to form a rigid tail club handle). Our phylogenetic analysis on a dataset comprising 59 taxa and 191 characters places Megamastax amblyodus, including an articulated one with part of trunk and nearly complete head and cheek bones, have been found from the type locality and horizon. After almost two years' mechanical preparation, the articulated specimen has been CT scanned to reveal details of the neurocranium, palatoquadrate, dermal skull roof and cheeks, and dentition. The braincase lacks an intracranial joint and has chondrichthyan-like enclosed aortic canals. The dermal cheek bones resemble those of primitive osteichthysans such as Pnaolepis and basal actinopterygians, but the skull roof pattern differs dramatically from known osteichthysans and instead resembles the "maxillate palatoquadrate" Enalchnathus. Structures previously described as "bent coroid teeth" are actually the attachment bases for tooth cushions like those of the stem osteichthysans Lophosteus and Andreolepis. The squamation is composed of very small and thin rhomboid scales, and lacks large median dorsal plates. A combination of chondrichthyan and osteichthyan and placodont traits is unique and unexpected. It suggests that Megamastax occupies a position close to the gnathostome crown group node and opens novel perspectives on how early osteichthyans evolved their diagnostic features.

Grant Information:
Strategic Priority Research Program of Chinese Academy of Sciences (XDA20000000,XDA19050102, XDB26010040), and National Natural Science Foundation of China (41530102).

Technical Session X (Friday, October 11, 2019, 8:15 AM)

A NEW SILURIAN BONY FISH CLOSE TO THE COMMON ANCESTOR OF CROWN GNATHOSTOMES

ZHU, You'an, Institute of Vertebrate Paleontology and Paleanthropology, Beijing, China; ZHU, Min, IVPP Academia Sinica, Beijing, China; LU, Jing, Institute of Vertebrate Paleontology and Paleanthropology, Beijing, China; AHLBERG, Per E., Uppsala University, Uppsala, Sweden; CUI, Xindong, Institute of Vertebrate Paleontology and Paleanthropology, Beijing, China

Modern jawed vertebrates or crown-group gnathostome include the last common ancestor of living bony and cartilaginous fishes and all its descendants. The gross morphology of the earliest modern jawed vertebrates, and how they arose from stem gnathostomes, were previously unknown due to a lack of articulated fossils. The recent discovery of the Xiaoxiang Fauna from the Silurian of South China revolutionarily adds to the diversity of Silurian jawed vertebrates. However, considerable morphological gap is still present between stem- and crown-group gnathostomes. Here, we report a new bony fish very close to the crown-group gnathostome node, also from the Xiaoxiang Fauna. The attributed specimens include a head, jaws and an articulated postcranal skeleton. The new fish displays a unique suite of characters: the dermal pectoral girdle condition transitional between Enelognathus and osteichthysans, the braincase profile recalling the condition in Hexameryx and early chondrichthysans, and the premaxillary and vomerine bone largely showing osteichthyans features. This mosaic character combination suggests the tentative phylogenetic position of this new taxa in the most basal segment of the osteichthyans stem, possibly forming a quintessential component of the evolutionary transition between placoderms and osteichthysans. For the first time, we are able to look into a near-complete bony fish close to the last common ancestor of all the living jawed vertebrates, and reconstruct the acquisition sequence of osteichthyans characters based on a set of fossils in morphological proximity. The new fish displays a unique suite of characters: the dermal pectoral girdle condition transitional between Enelognathus and osteichthysans, the braincase profile recalling the condition in Hexameryx and early chondrichthysans, and the premaxillary and vomerine bone largely showing osteichthyans features. This mosaic character combination suggests the tentative phylogenetic position of this new taxa in the most basal segment of the osteichthyans stem, possibly forming a quintessential component of the evolutionary transition between placoderms and osteichthysans. For the first time, we are able to look into a near-complete bony fish close to the last common ancestor of all the living jawed vertebrates, and reconstruct the acquisition sequence of osteichthysans characters based on a set of fossils in morphological proximity.
Isolated teeth dominate the Australian fossil record of Cenozoic sharks and rays (Chondrichthyes). Associated chondrichthyan remains preserve extremely rarely in the fossil record, due to the group’s weakly articulated and mostly cartilaginous skeletons. Until now, an underscribed partial lamniform shark fossil from the Lower Miocene Batesford Limestone comprised the only report of an associated shark fossil in the Australian Cenozoic. Many fossil taxa erected from isolated shark teeth worldwide are of dubious value, confounded by morphological differences due to tooth position, ontogenetic variation, and intraspecific variability. Associated specimens are also productive sources of biostatimetric and taphonomic context, and can inform paleoecological interpretations of depositional environment.

We report on the discovery of a partial associated specimen of the lamniform shark *Carcharocles angustidens* (NMV P253894) in the upper Oligocene (25.23 Ma) Jan Juc Marl in Victoria, Australia. This third known example worldwide represents a notable expansion of the heretofore sparse and isolated chondrichthyan fossil record from this rich fossiliferous coastal outcrop. The specimen, representing an individual of total length ≤7.7 m, comprises 16 functional erupted and 17 incompletely developed unerupted teeth, including representative examples of anterior, intermediate, lateral, and posterior files, and one associated fragmentary vertebra. This assemblage was further augmented by the discovery of 12 fossil hexanchid shark teeth (NMV P253894) associated with the *C. angustidens* remains. All are erupted and well-preserved, showing no evidence of digestion, but several display mechanical damage to tooth crowns.

We suggest this specimen preserves a shallow-water “shark-fall” faunal assemblage, with initial exploitation of the *C. angustidens* carcass by hexanchid sharks within days to months of its arrival at the sea floor. Fossilised invertebrate epifauna preserved on the vertebra surface indicate the subsequent development of invertebrate faunal communities, including sulphophilic direct scavengers and suspension feeders exploiting hard substrata. Most such communities, fossil and modern, have been observed on whale-fall carcasses, but few whales globally reached or exceeded the size of large lamniform sharks from the Oligocene to late Miocene. This discovery further augmented by the discovery of 16 functional erupted and 17 incompletely developed unerupted teeth, including representative examples of anterior, intermediate, lateral, and posterior files, and one associated fragmentary vertebra. This assemblage was further augmented by the discovery of 12 fossil hexanchid shark teeth (NMV P253894) associated with the *C. angustidens* remains. All are erupted and well-preserved, showing no evidence of digestion, but several display mechanical damage to tooth crowns.

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